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MANCHESTER AND ITS SHIP CANAL.

On Saturday, Oct. 3, 1885, the people of the city of Manchester and the adjacent borough of Salford, which are separated only by the river Irwell, joined with striking enthusiasm in a grand open-air demonstration of their satisfaction at the passing of the Manchester Ship Canal Bill. The essential part of the scheme is deepening and straightening the channel of the Irwell and Mersey, from Manchester to Runcorn, for the admission of large ships, with the construction of docks at Manchester. In the part which relates to the channel through the estuary of the Mersey, considerable alterations have been required, so as to prevent injury to the approach to the Liverpool docks, and the Parliamentary contest has been very expensive; but there is no doubt of the feasibility of the work as an engineering problem. Its cost, which will probably exceed six millions sterling, and the prospect of a remunerative profit to the subscribers, may be left to the consideration of those who are invited to supply the capital; but the Manchester people generally expect great local benefit from its execution, and seem very willing that it should be undertaken by a company of shareholders at private risk.

The demonstration of Oct. 3 was of an imposing and thoroughly popular character. Its chief heroes were Mr. Daniel Adamson, a civil engineer of Manchester, who is the energetic founder and chairman of the Ship Canal Company; Mr. E. H. Pember, Q.C., who has ably conducted its case before the Parliamentary Committees; and Mr. E. Leader Williams, engineer to the company, who has prepared all its plans, and is fully competent to execute one of the greatest works of this nature. The meeting also gained official sanction by the presence of the Mayors and Corporations of Manchester and Salford, and it was joined by Mr. Jacob Bright and Mr. W. H. Houldsworth, two of the members for the city; and a number of members of the Provisional Committee. The procession assembled in Albert Square, in which the Manchester Town Hall is situated, and marched, the bulk of them, to the Belle Vue Gardens, and the remainder, the temperance men, to the Alexandra Park. The streets through which the procession passed were decorated with flags, trophies, and appropriate emblems or mottoes; and for the most part were crowded with spectators, who cheered Mr. Adamson, the members of the Corporations, and others whom they recognized. Not less than fifty-three trade and friendly organizations took part in the proceedings, and the demonstration was augmented by the presence of several thousand persons connected with various temperance institutions, such as the Local Temperance Union, the Order of Rechabites, and the Order of Good Templars. It is impossible to estimate with any accuracy how many persons joined in the procession, but the total was not much less than thirty thousand.

MR. E. LEADER WILLIAMS, C.E.,
ENGINEER OF THE MANCHESTER SHIP CANAL.

MR. DANIEL ADAMSON, C.E.,
CHAIRMAN OF THE PROVISIONAL COMMITTEE OF THE SHIP CANAL.

MR. E. H. PEMBER, Q.C.,
LEADING COUNSEL BEFORE THE PARLIAMENTARY COMMITTEES.

MANCHESTER SHIP CANAL CELEBRATION.—HEAD OF THE PROCESSION AT THE CORNER OF PICCADILLY.

The route to Belle Vue was a very circuitous one. After leaving Mount Street, the procession went by way of Peter Street, Deansgate, Bridge Street, over the Irwell to New Bailey Street, Salford, Chapel Street, Victoria Street, returning across the river to Victoria Street, Market Street, Portland Street, Oxford Street, Brunswick Street, and London Road or Hyde Road to Belle Vue. Along the whole route the people were massed behind the barricades; hardly less so in the Salford streets than in the principal thoroughfares of Manchester. In many places stands had been erected for the accommodation of sightseers, from which a good view of the procession could be had. The windows of the shops and houses were filled with bright faces, and the whole course of the procession was a continued triumph.

The procession was headed by an open carriage, in which sat Mr. Daniel Adamson, Mr. Pember, and Mr. Leader Williams; the members of the Provisional Committee followed their chairman. The carriages contained Mr. Jacob Bright, M.P., Mr. Houldsworth, M.P., the Mayor of Stockport, Mr. George Hicks, Mr. Councilor Boddington, Mr. W. J. Saxon, Mr. Alderman Bailey, Mr. Alderman Husband, Mr. William Fletcher, Mr. Marshall Stevens, Mr. Alderman Walmsley, Dr. Mackie, Mr. Richard James, Mr. Thomas Bradford, Mr. Henry Whitworth, Mr. C. L. Sampson, Mr. Edwin Guthrie, Mr. Frederick Moss, Mr. H. C. Pingstone, Mr. C. H. Wade, Mr. Clement Walmsley, Mr. J. W. Harvey, Mr. Reuben Spencer, Mr. Paul Gariel, Mr. James Johnston, Mr. John Walker, Mr. Edward Walmsley, Mr. Melton Prior, our special artist, and Mr. A. H. Whitworth.

The societies fell in behind the carriages. The Ashton Unity of Shepherds had the first place, and the procession was made up in the following order. We quote from the official programme, which also gives the expected strength of each society. For the actual figures some little deduction would have to be made in most cases.

Loyal Order of Shepherds (Ashton Unity)	1,000
Plumbers' Operative Association	200
Boiler Makers and Iron Shipbuilders	1,000
Operative Cabinet Makers	200
Carriage and Wagon Makers' Amalgamated Society	300
United Kingdom Society of Coach Makers	500
Grand United Order of Oddfellows	1,800
Amalgamated Society of Engineers	3,000
Saddlers' Union (Manchester Branch)	150
Bakers' Operative Friendly Association	100
Cabinet Makers' Alliance	400
National Association of Plasterers, Manchester District	150
Manchester Warehousemen	500
Tinplate Workers' Association	500
Iron Dressers' Trade Society, Manchester and Salford	800
House Painters, Manchester and Salford	350
Manchester and Salford Operative Lathmakers	70
Amalgamated Union of Bakers and Confectioners	300
The Blind Workshops	40
Twisters and Beamers' Association	400
Amalgamated Society of Carpenters and Joiners	1,000
United Kingdom Society of Hammermen,	500
Manchester and Salford Branch Ironfounders' Friendly Society	800
Lithographic Printers	200
National Society of Brassworkers	350
Flint Glass Workers' Association	450
Dressers, Dyers, and Finishers' Association	1,500
French Polishers' Association	100
National Independent Order of Oddfellows	1,200
Typographical Society	500
Amalgamated Society of Boot and Shoe Makers	170
Amalgamated Society of Packers	500
Amalgamated Mill Sawyers	200
Loyal United Order of Oddfellows' Friendly Society	300
Power Loom Overlookers' National Association	150
Ancient Order of Foresters	2,500
United Machine Workers' Association	300
Brass Founders' Association	100
Nottingham Ancient and Imperial Order of Oddfellows	1,000
Ancient Noble Order of United Oddfellows (Bolton Unity)	1,700
Bookbinders and Machine Rulers' Consolidated Union	200
Operative Society of Bricklayers	100
Brushmakers' Association	100
Amalgamated Society of Tailors	500
Card and Blowing Room Association	200
Manchester Association Trade and Friendly Society of Coopers	200
Steam Hammer and Blast Furnacemen's Association	100
Umbrella Frame Makers' Society	130
Operative Stonemasons' Society	600
Commission Agents	100
Wheelwrights' and Blacksmiths' Society	300
The Mayors of Manchester and Salford and the members of both Corporations.	
Manchester and Salford District Temperance Union; Independent Order of Good Templars; Independent Order of Rechabites, No. 1 District; Sons of Temperance; Independent Order of the Sons of Temperance; Daughters of Temperance	600

The two mayors (Mr. Alderman Harwood, of Manchester, and Mr. Alderman Makinson, of Salford) rode in the same carriage. They were preceded by the police bands of both boroughs, and attended by mounted constables. Behind the Corporations, and in the rear of the procession, came the temperance societies. These latter did not go to Belle Vue, but to Alexandra Park.

Some features of the procession were original and characteristic. The Boiler Makers and Iron Shipbuilders' Society carried the model of a large screw steamer, such as they hope to build at Manchester. The carriage and wagon makers bore aloft some miniature tram cars and a luxurious railway saloon. The engineers made the most imposing show of numbers; there were nearly three thousand of them, and they stretched to about a third of a mile. The bakers had with them a van bearing an enormous loaf in a boat, which was named the "Daniel Adamson." The tinplate workers had made a suit of armor for their standard bearer, which made him one of the most admired figures in the procession. The flint glass workers made one of the most popular shows; every man of them wielded a glass sword, and many had glass helmets which sparkled very prettily. The Foresters' and Oddfellows' orders were arrayed in all their costume and insignia, and the sashes of red and green were not without effect in the long line. Above the Foresters was carried a large model showing a powerful tug bringing a ship freighted with cotton up the canal. The bookbinders had with them an enormous volume, entitled "The Revival of Lancashire Industries, by Daniel Adamson"; on the upper side of the book was a schooner in full sail. The umbrella makers of course carried umbrellas, which were of various colors, and were rather a striking feature in the show.

It was after two o'clock before the Mayors and their Corporations left the Townhall. At the same time, the head of the procession reached the Hyde road entrance to Belle Vue Gardens, and for an hour and a half an unbroken stream of people poured through the gates. It was close upon four o'clock when the Mayors of Manchester and Salford arrived at Belle Vue, accompanied by the members of the two Corporations, Mr. Jacob Bright, M.P., Mr. W. H. Houldsworth, M. P., and many others. An assembly of twelve or fifteen thousand people, standing in the Gardens, on and around the outdoor dancing board, was addressed by several gentlemen from the balcony of the grand stand. The Mayor of Manchester, who presided, expressed the hope that the undertaking would be brought to a successful issue. Mr. Adamson said he was quite sure that Lancashire would find the means for constructing the proposed waterway, and so would reap the profits from the undertaking. He was sure that before six months were over they would have another gathering for the purpose of cutting the first turf and beginning the work of excavation with ten thousand navvies. Mr. Pember, who, like Mr. Adamson, was enthusiastically cheered, said that in this matter the whole population of Lancashire understood what was their interest, and the project was supported, not by the few, but by the good sense and clear sight of the many. Mr. Jacob Bright, M.P., remarked that they were met to celebrate a victory which had cost no blood and done no harm to any one, and whose results would bring no inconsiderable advantages to their commerce and industry. Mr. Houldsworth, M.P., said no one could, after that demonstration, doubt that Lancashire was in earnest about this matter. Resolutions were unanimously passed congratulating and thanking Mr. Adamson, Mr. Pember, and others who had labored on behalf of the bill, and pledging the meeting to support the Committee to the utmost of their power by taking up shares in the Ship Canal Company.

The Mayors of Manchester and Salford, with Mr. Adamson and Mr. Pember, afterward went to the Alexandra Park meeting. Representatives of the different temperance organizations delivered addresses, and the following resolution was unanimously adopted: "That in the opinion of this meeting of the citizens of Manchester and the vicinity, the speedy completion of the Manchester Ship Canal is of vital importance to the well-being of the trade and commerce of this city; and that the more speedy enactment of a direct veto of the liquor traffic will do still more to promote the trade and prosperity of the whole country." Another resolution was adopted by which all teetotalers were urged to join one or other of the temperance benevolent societies.

On Monday evening following, there was a great meeting at the Free Trade Hall, and on Tuesday a banquet given by the Corporation of Manchester at the Townhall.

We give portraits of Mr. D. Adamson, C.E., Mr. E. H. Pember, Q.C., and Mr. E. Leader Williams, C.E., whose labors have so far been successful in obtaining Parliamentary sanction for this great enterprise.—*Illustrated London News.*

On another page we give an engraving of the locks of the Manchester Ship Canal.

METALLIC RAILWAY TIES.

AT a recent meeting in Paris of the French Society of Civil Engineers, a paper by M. Post, of Holland, upon "Metallic Railway Ties" was noted by M. Auguste Moreau, who said that the author first referred generally to the growing scarcity of wood for this purpose, and the urgent necessity of providing a substitute therefor; he mentioned that M. Post had regretted that the study of this subject should have been so much delayed in France.

According to the author of the paper discussed, the principal advantages inherent in the new system, advantages based on an actual trial of about twelve years in Germany, etc., were:

1. The average durability of the ties remaining in the track after 12 years' use is much greater with metallic ties of a good design than with the best wooden ties.

2. Safety is better guaranteed, as the gauge is better preserved.

3. The expense of maintenance is decreased after the second year of service, while with wooden ties this item increases with the age of the ties.

4. That the system is being rapidly perfected, so that the fastenings are being made absolutely certain and less expensive for repair and maintenance than the fastenings used with wooden ties.

5. The value of the metallic tie when worn out in service is much greater than the value of an old wooden tie.

In summing up these advantages, and combining them with the actual cost of purchase, redemption, and interest, M. Post concludes that no country can exclusively use wood for this purpose with true economy; and he cites Holland as a proof of his assertion, where wood is still easily obtained and manufactured, and iron is not too plentiful. He says *all* the Holland companies have adopted the metallic tie.

The first ties failed from being too light in section; as the engineers had originally endeavored to give them such a weight that they would not exceed wooden ties in first cost. By so doing they fixed upon a weight of from 60 to 66 pounds for each tie; this was insufficient, and the portion of the tie supporting the foot of the rail was particularly weak.

The reasons given for the failure in the last named parts of the tie were: The openings in the tie for the attachment of the fastenings sensibly reduced the section; the punching made the metal break in the neighborhood of these holes, especially when hard steel was used; the foot of the rail and the fastenings embedded themselves in time in the upper surface of the tie; the shock from passing wheels was transmitted to the portion directly under the tie; and in several types of ties, this part is weakened by the manufacture and by bending, being either bent cold or stamped hot to give it the inclination of 1 in 20 in its length.

To overcome these disadvantages, the weight of the tie was finally increased to 165 pounds, but these ties, while giving excellent results in practice, proved to be too expensive. Many attempts were then made to re-enforce the weak points by means of plates or saddles attached by rivets, bolts, keys, etc.; but these more complicated accessories again increased the cost of the tie, and the reliability of contact between the rail and tie became less certain than when the rail rested directly on the tie.

As a result of all this experience and trial, M. Post described the type of tie having the fewest weak points and disadvantages. The base of his process consisted in so rolling the metallic tie that on leaving the rolls it already had the wished for inclination of 1 in 20 on the upper surface, and the parts intended to carry the rail were already sufficiently re-enforced with an extra thickness of metal. In section the tie resembled a letter U reversed, and more or less widened out at the base. He preferred the section adopted on the Netherland State railways, in which the tie does not exceed 110 pounds in weight, is easily rolled, presents a large surface of contact to the foot of the rail, and is readily tamped with any kind of ballast.

In the manufacture of this tie, mild steel (Thomas or Bessemer) was used to avoid the dangers of fracture arising from punching or stamping in hard steel. For the same reason the rectangular holes have their corners and edges rounded, and the fastening bolts have correspondingly rounded edges on their heads. Before closing the ends of the ties by stamping, the metal is annealed.

The fastening is simple and certain, but cannot be very well described without an illustration. The slipping of the rail longitudinally is stopped by the use of clamps connected with the rail joint.

The spacing of the ties is about the same as for wooden ties; there are ten to a rail 9 m. (29·52 feet) long, the mean distance between centers of ties being 0·962 m. (3 feet 2 inches) and 0·57 m (1 foot 10⅜ inches) at the joint.

In commenting generally upon the system, M. Post said that on new made embankment or poor ballast, it was better to use the wooden tie; but when the bank had become solid, and all settlement had ceased, he favored the metallic tie, costing from 25 to 30 per cent. more than the wooden tie.

In regard to France, M. Moreau, in commenting on the regret of M. Post, said that the principal railway companies of that country were not yet entirely convinced as to the necessity of using metallic ties. They made use of excellent wooden ties, which are not yet too costly, and in hard wood, creosoted, they would last from 20 to 25 years. Under these conditions their enthusiasm for the new system was not pronounced.

DIVIDED CAR AXLES.

ON the 6th day of December, 1884, a test of the Bedbury divided car axle was made on the Oregon Railway and Navigation Company's road in Oregon, under the supervision of President Gilbert of the Oregon Construction Company, he having been selected by the O. R. & N. Co. to superintend said test. The following is a summary:

A flat car fitted with the divided axle, and loaded with fifteen tons of steel rails, and a similar car fitted with a rigid axle with a duplicate load, were placed upon a level stretch of track, running from a tangent on to a ten degree curve. The car with a rigid axle was coupled to a locomotive by a dynamometer (an instrument for measuring resistance), with the following result: At a speed of three miles an hour, on the straight work, the resistance was two hundred pounds, but on the ten degree curve it was six hundred pounds, showing four hundred pounds of curve friction.

Then another trial was made, increasing the speed to thirteen miles per hour, and which, as the centrifugal force was greater and more binding on the rail, showed seven hundred pounds, or five hundred pounds of curve friction. The divided axle was then tried with this result:

On the straight work two hundred pounds, the same as the rigid axle. At a three mile speed on the curve, the indicator just quivered, it did not register a pound more than on the straight work; but on the higher rate of speed, owing to the centrifugal force as before stated, it showed just fifty pounds of curve friction.

A division of the two tests shows 450 pounds for the rigid axle against 25 pounds for the divided axle, which makes a reduction of ninety-four and one-half per cent. in favor of our divided car axle.

This test was made in the presence of Superintendent H. S. Rowe, Comptroller C. J. Smith, Roadmaster Shaw, and Yardmaster Grimes, all of the O. R. & N. Co., of Oregon.

The reason why an axle is made smaller in its center is to reduce vibration, but it only partially does so. Wheels are now forced on axles with from twenty to thirty tons pressure. The result is obvious, for by so doing the axle is gripped so tightly that all the pores of the iron are closed, no vibration can pass through the wheel-seat and distribute itself; but the vibration passes from the wheel-seat to the center and back, comes in contact with itself, crystallizes the iron in the axle at the wheel seat, and always breaks in its very largest place, owing to the physical fact of crystallization. But when an axle is divided, the vibration ceases at the disconnection, cannot therefore return, and crys-

tallization as well as vibration are largely done away with.

Admitting, for argument's sake, that vibration will return, there is no need to press a wheel on with over seven tons pressure; as there is no longer any wrenching strain, and the pores of the iron are not closed, the vibration can pass through the wheel seat and distribute itself on the rail as the train moves. So by dividing the axle we add fifty per cent. to the life of the axle.

We add fifty per cent. to the life of the wheel, for the simple reason that with a divided axle the wheels are always rotating, never sliding, consequently no flat places are worn on the said wheels. Flat wheels are of great annoyance and inconvenience, producing unnecessary vibration, as well as a matter of much expense and delay to railroad companies.

It has been estimated that the wear and tear on sixty miles of curve road entailed an expense equal to the interest on one million of dollars per year.

By dividing an axle, we can dispense with, if necessary, the present system of coning wheels. One reason why wheels are coned is to partially accomplish what a division of the axle wholly accomplishes, viz., to reduce curve friction; that is, by drawing one wheel to its smallest point and the other to its largest part.

Yet it is well known that the benefits to be derived from the use of coned wheels do not compensate for the extra wear and tear produced on heavy freight work. Coned wheels produce an undue and unnecessary friction on a straight road, and have a tendency to spread the rails. So that using coned wheels on a comparatively straight road is poor policy, for the reason that an unnecessary friction is caused for miles to benefit a few feet of curvature.

By dividing an axle, roads can safely come back to the old flat tread wheel, get the full support of the T, and not wear off the inner part of the rail or batter it down, long before the rail has half lived its usefulness. So by dividing an axle we add fifty per cent. to the life of the rail.

The great comfort given to passengers when rounding curves with the divided axle. One experiences none of those grinding and grating noises or electric shocks always felt on curves with the present axle. Ease, comfort, and steadiness are produced by our axle; for the divided axle virtually turns, as it were, a curve into a straight road or tangent.

Railroad companies will find the divided axle of great benefit in the construction of new roads. They can, with this axle, build roads through portions of country heretofore impracticable, and at comparatively small figures; because, with this new device, they can accommodate the *curve* to the axle, thereby often avoiding the necessity for great tunneling or steep grades. Small as this may at first seem, it will be found of great benefit, not only in point of time, but also as a matter of strict economy.

It is very plain that in the rounding of curves the outside rail is longer than the inside one, and as a consequence one wheel, with the rigid axle, is obliged to slip and slide along the rail the distance that it is greater than the other. Now, if the wheel strike, while so sliding, a depressed joint, or in winter a very open joint or a rough place, it will bound four times higher than if it were rolling. If it bound so high that the flange clears the top of the rail, as often happens, the centrifugal force, which is outward, will carry off the truck and wreck the train. In nine times out of ten when a train leaves the track it is on a curve. Trains have been known to run down grade at the rate of sixty miles an hour, and keep the track until reaching a curve. One such accident would more than pay for the change of axles.

With this axle such accidents could not happen, for the reason that both wheels are kept constantly rotating, never sliding and never bounding. The division being at the center, one wheel compensates for the other. Really considered a life saving invention; for by using it all such accidents may be avoided.

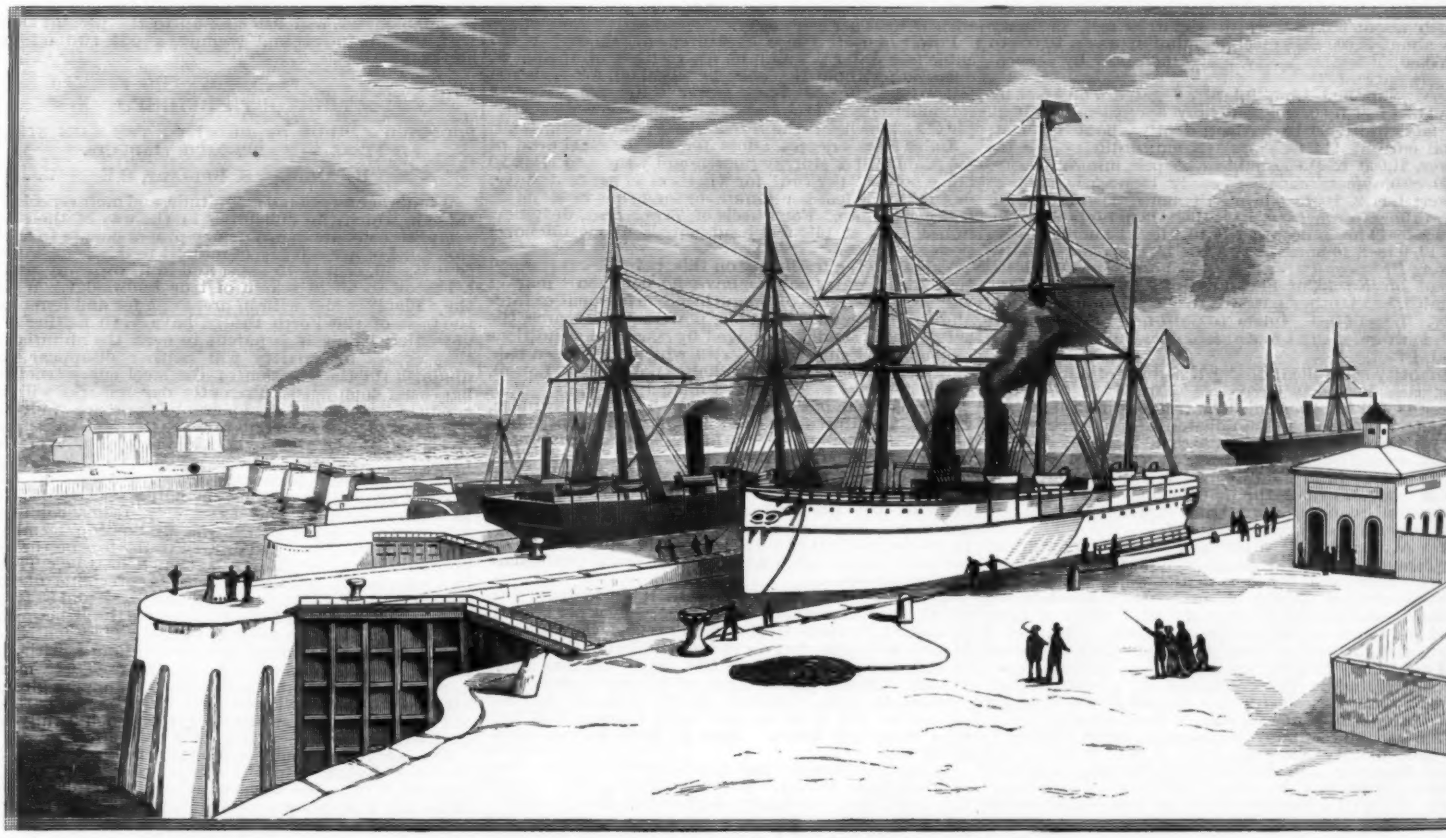
The benefits of a divided axle are well known to all railroad men, and the only question heretofore has been, Can one be made which embraces the following qualifications, viz., strength, durability, proper facilities for lubricating, dust proof, oil proof, adjustable, economical, and perpetual?

This axle embraces all of these qualifications, and is eminently superior to any axle ever yet produced. It has an automatic oil feed, the oil cannot escape, and can be lubricated from the outside of the car.

All the old axles now in use can be remodeled to this form at a trifling expense, and the coupling is everlasting.

LOCKS OF THE MANCHESTER SHIP CANAL.

AT Latchford, some 15 miles from the Manchester dock, it is intended to construct a dock for the accommodation of Warrington; and there are to be coal docks at Irlam and Barton. The canal locks at these places are of compound design; at Latchford there will be a group of three locks of different sizes, placed side by side. The largest will hold several ships at once, but they will have intermediate gates, to allow a part of the lock to be used without waste of water. Hundreds of vessels may thus pass these locks in a day. The Irlam and Barton locks are to be similar in design, but without tidal gates. The gates and sluices will be worked by hydraulic power, but steam power will also be provided. In other respects, the locks on the Manchester Ship Canal will be constructed very similar to each other, so that in illustrating one of these locks from the engineers' designs, a very good representation of the various locks on the canal route is afforded to the reader, so that we need only add that in its course the canal will ascend five of these locks.—*Engineering Review.*



LOCKS OF THE MANCHESTER SHIP CANAL.

WATER POWER AT NIAGARA FALLS.*

By SAMUEL MCELROY, C.E.

UNDER an act of April 30, 1883, of the New York Legislature, five commissioners were appointed to locate a public park at the village of Niagara Falls, which has been laid out to include the water front for about one mile above the Falls, Prospect Park at the Falls, with Bath, Luna, Goat, and other islands on the American side.

Under this act three commissioners were appointed by the Supreme Court, to appraise the value of the lands and other property appropriated for this park, who commenced their sessions in February, 1884, and made a report October 27, awarding an aggregate sum of $1,443,439, provided for by a Legislative act of April 30, 1885.

The hydraulic power has been utilized by the hydraulic canal, Witmer's grist mill, the upper and lower races and the paper mill on Bath Island; below the falls by Witmer's grist mill at the Suspension Bridge.

The hydraulic canal, about 4,000 feet long, runs from Port Day, a point just above the rapids, to a basin near the ledge on the American side, about half a mile below the fall. It varies in width from 36 to 74 feet, minimum depth about 7½ feet, and supplies 10 mills, using about 3,100 horse power; a new flour mill is being built to use 1,000 horse power additional. Advantage is taken of the ledge height by tunnels to obtain wheel heads of 50 to 90 feet, turbines being used. This is not included in the park.

The Witmer mill, on the river rapids, was built in 1800. It has four runs of stone, driven by three "Eagle" turbines, and one "tub" wheel, under a head of about six feet.

Two mill races were laid out near the falls, the "upper" and lower," parallel with each other, fed by the rapids. The former is used for light hotel power; the other has been long in use. Its original wing-wall was extended into the rapids in 1820-21. It furnishes power for two pumps, two carpenter shops, one cabinet and one machine shop, a large pulp-mill, and the dynamo engine and water wheel of Prospect Park and its ferry railway.

On Bath Island, power is used from the rapids for a large paper mill, with two 54 and one 66 inch "American" turbines; head, 12 to 13 feet; about 400 horse power used. These powers were appropriated.

Lower Race Power.—In 1882 an action was commenced by an owner on the lower race, Mrs. Townsend, to obtain a decree fixing the relative supply of water to the several lots, twelve in all on the race, and Prospect Park, claiming one lot, and a decree was rendered September 25, 1884, by Judge M. H. Peck, referee.

This case became an elaborate investigation of the conditions and value of water supply and power here, and furnished an important basis for the State case testimony, but the decree was not published when the appraisers concluded their awards, and is now the subject of an appeal to the Court of Appeals. Practically, the suit was an attempt to restrict the supply of the pulp mill, which has the first to properly develop this race, the defendants being Messrs. Hill & Murray, its owners.

For the plaintiff Messrs. C. H. Rhodes and C. H. Pifer were counsel; Messrs. C. S. Olmsted, L. E. Nichols, Benj. Rhodes, civil engineers; Prof. I. F. Quimby, A. P. Burdick, and J. Phillips, machinists, as experts. For defendants, G. J. Sicard, Esq., counsel; W. F. Noye, M. S. Otis, W. A. Philpot, millwrights and machinists, as experts. In the State case, where value of power became prominent, the witnesses for Hill and Murray were Clemens Herschel, C.E.; R. Rossiter, Supt. Paterson power; W. H. Nixon, paper manufacturer; D. T. Mills, turbine builder; Messrs. Noye and Otis, several machinists, and Samuel McElroy, C.E., consulting expert, in both cases.

The several points presented may be thus stated:

Relative value of water power depends on the quantity, head, and regularity of supply, and its purity; on facilities for receipt and delivery of supplies and productions, and for labor and repairs; on the perfection of mill and machinery, and operation; quantity legally controlled; local conditions, and standards of similar power.

Quantity of supply: Source, Lake Erie; distance by river, 22 miles; time of river flow, 6 hours; flow of river, about 18,000,000 cubic feet per minute; power of whole falls, at 150 feet, 3,600,000 horse power on shaft; area of lake, 9,600 square miles; fluctuating range, about 1·8 feet; prevalent winds, W. and S. W., tending to keep up levels for about 70 per cent. of annual gales; flow uniform, day and night.

Race obstruction, by sludge ice, not to exceed a week in winter; cost to clear, about $350; winds produce occasional changes up to 1·5 feet; tail races rise and fall with inlet; virtual fall not impaired.

As compared with other powers, the Merrimack at Lawrence, draining 4,453 square miles, fluctuates from about 2,600 cubic feet per second in September to 18,000 in May; the general variation of head at Lowell is 5 feet on the upper fall of 32, and a reduction of 6 feet is sometimes caused by floods; the best head, where dams are used (from flood rise on the tail races), being in dry weather, if the supply does not fail. The Connecticut, at Holyoke, varies from 36,000 cubic feet to less than 2,500 per second; the Housatonic, at Kent, from 887 cubic feet per second in May to 263 feet in August; the Mohawk, at Cohoes, draining 2,530 square miles, runs down to 980 cubic feet per second,

* Read Sept. 1, 1885. From Journal of the *Association of Engineering Societies.*

mill supply, in the dry season; the Genesee Falls are often dry at Rochester. Water wheels are subject to serious ice obstructions in winter; and few mills can be run, day and night continuously, summer and winter, as on this race.

Relative levels above mean ocean level: Lake Erie, 575* feet; Gill Creek, mouth, 566; Port Day, 564; Upper Race Inlet, 560; Lower, 542; Top American Fall, 515; Bottom, 350; Lewiston, 248·5; Lake Ontario, 246·5. Rapids fall about 46 feet in three-quarters of a mile.

Purity of water supply may affect the durability of turbines by comparative wear, and does seriously affect the value of certain productions, like paper pulp. The race supply differs essentially from that of Bath Island in this respect, and the pulp commands a better market. The depurative effect of Lake Erie on mechanical and organic impurities is important.

Freight facilities: With seven trunk railways, West, South, and East, and with river, canal, and lake navigation, direct access is had to the best supplies of timber at the lowest cost, and sharp competition exists for receipt and delivery of mill supplies and productions. Railway rates for pulp per 100 pounds to New York, 13 cents; Boston, 18 cents; St. Louis, 15 cents; Chicago, 13 cents; Wilmington, 15 cents; pulp from Paterson to New York, 17 miles, 9 cents; paper, Philadelphia to New York, 90 miles, 17 cents; rates from Holyoke much higher than Niagara. Labor and repairs, for the same reason, can be promptly and cheaply had.

Mill and machinery are of the best type. Mill of stone work on rock foundations; steel shafting; one 13, one 54, one 66 inch "American" center bent wheels of the best pattern; Otis patent pulp grinders of high efficiency; electric lights; machines of the best pattern, operated day and night, except Sundays.

Inlet, formed by a wing-wall built into the rapids, which fall 18·44 feet in 0·224 mile, above it, and enter them with chutes of 17 to 20 feet per second velocity; length about 360 feet, width about 50 feet, ordinary flow about 72,000 cubic feet per minute; waste, 30,000 to 37,200 cubic feet; capacity easily increased by deepening the entrance.

Race: Supplied from inlet by 9 gates, 6 of 4 feet by 4½, 3 of 4 feet by 5, seldom fully open; length, about 645 feet; width, 30 to 25 feet; depth, about 7½ feet; usual current, 1½ feet per second; ordinary use for power, 31,000 to 41,000 cubic feet per minute; waste, 3,800 cubic feet; capacity easily increased. Use of power: Lot 2, 5½ feet head, 5½ horse power; No. 4, 8 feet, 12 horse power; No. 6, 17½ feet, 18 horse power; No. 8, 12 feet, 12 horse power; No. 10, 9 feet, 30 horse power; No. 12, 9 feet, 10 horse power; No. 16, 17½ feet, 425 horse power; Prospect Park, 12 feet, 25 horse power; wheels, except on No. 16, of low duty, of "Tub," "Flutter," "Smith," and other patterns, from 20 to 30 per cent. duty. Loss of head, inlets to pulp mill forebay, inlet, 0·20 foot; gates, 0·25 foot; arches and race, 0·55 foot; total, 1 foot.

Quantity controlled: Under the grant of January 30, 1840, each lot on this race was entitled to "so much water as will be sufficient, by a prudent use thereof, to drive two runs or pairs of millstones, upon such water-saving principles as are usually adopted by skillful engineers and builders."

The proper interpretation of this grant was the key to the contest before the Referee, and on the supply and power required for a "run of stone" in 1840 the following testimony was presented:

Run of stone: The "shaft" power required for grinding depends on careful adaptation of their structure, forms, weight, and bearings to the work; diameter, or rubbing surfaces; sharpness, or "dress"; durability of surface; coarseness or fineness of "set"; speed; weight, hard and tough or soft texture, moisture or dryness of grain, and fineness of flour produced. The power for mill machinery in elevating, separating, bolting, cleaning, or regrinding the grain and its products is additional, and varies with relative perfection of design and workmanship, and amount of work required.

Similar pairs of buhr stones may differ at times 33 per cent. in duty (Emerson, Hyd., p. 297); former 5 and 6 foot diameters are reduced to 4½ or less, to reduce friction; neglect of dress may reduce 11⅛ bushels per hour to 5⅝ (D'Aubuisson, Hyd., p. 450). One run in five or six is generally idle for dressing; 16⅔ to 20 per cent. more power required on runs at work; old speed of 90 to 100 revolutions, or high speed of 175, modified to 150, for 10 bushels per hour. Weight per bushel: Wheat 60 pounds, flour 40, corn 56 pounds, meal 55, rye 56 pounds, flour 22½, oats 31 pounds, meal 16⅝; with corn, as standard, 4½ per cent. more or 45·7 less weight in grain, and 61·54, or 40 in flour. Resistance of Dent corn or red wheat may be double that of softer grain; and thin shell, hard, spring wheat, or tough shell softer winter wheat, differ seriously. Moisture may add 22 per cent. resistance; grade of flower is also different. So, as to extremes, and not as to uniform conditions, D'Aubuisson (p. 449) concludes that "with the same fall, water, and stones," or power, "the quantity ground may vary as three to one."

Since 1870, the purifying and regrinding machinery has been added, and better machinery has been made for the same work.

Usual work: Taking wheat flour as standard, the power per run depends on the quantity ground, for which a moderate standard, determined from a large number of mills, was taken at ten bushels per hour.

The shaft power, deduced from a number of cases, for the best modern mills, for 10 bushels per hour, was taken as a minimum at 7·5 horse power for grinding, 4·5 mill machinery, wheel (75 per cent.) 4, or 16 "water" horse power in all.

Mill work of 1840: Except at a few centers, where active demand justified expensive wheels, pits, and machinery, much less perfect wheels and machinery were used, and greater power required.

The horse power standard of leading authorities in mill work of that day was above that of the present. Buchanan's Millwork, 1841, uses 44,000 foot pounds; Desagulier, the same; Watt, in practice, also; Evans (Millwright's Guide, p. 117) quotes 41,555 foot pounds British test; D'Aubuisson takes 40,302.

About 1 horse power per bushel per hour, or 1·22 to 1·33 standard, has been generally assumed as the grinding work of a "run."

D'Aubuisson assumes, for wheat, 1·29 horse power (standard), for grinding alone; a British government experiment quoted is 1·29 (standard).

For "water" power, ten cases cited by him, including mill machinery, average 4·744 horse power per bushel for 33·8 per cent. average wheel duty, or 2·672 horse power at 60 per cent., or 26·72 for 10 bushels per hour, this being the duty of the best Lowell wheels. Among these cases, Providence mills, 2·414 horse power per bushel; Bayard, Toulouse, 2·96 horse power (wheel, 43 per cent.), and a number of United States mills (from Evans) of 3·14 average, with 41 per cent. wheels.

Evans (p. 106), 5 foot "run," 97 revolutions, grinding only, 2·56 horse power "water;" p. 111, 2·61 horse power; p. 174, overshot, 4·63 horse power per bushel "water," at 60 per cent. wheel, 2·778 horse power "shaft."

In an Oswego case, an award gave with a Reynolds wheel (worth about 40 per cent. part gate, 50 per cent. whole gate), 38·59 horse power rate for 2,000 cubic feet on 10 foot fall.

This gives, for grinding, an increase from 7·5 horse power "shaft" of best modern mills to 12·5 to 26; and for wheels, runs, and machinery, an increase from 16 to 24, 25·6, 26·1, 29·6, 31·4, and 47·4 horse power, with wheels of varying duty and poorer machinery.

The deduction was 12 horse power wheel (60 per cent.), 13 grinding and 5 machinery, or 30 horse power in all, or 18 horse power "shaft;" ordinary wheels, not over half this duty.

Local conditions: In connection with this analysis it was shown that no local demand existed for any higher class of wheels or mills than those used for this or similar races, and any "skillful" engineer would adapt his structures to their uses at the time and place. With one railroad, to Lockport only, a canal not enlarged until 1852, 1,277 population in 1840 and 1,468 in 1850, and a superabundance of water, expensive wheels and pits would have been out of place. Undershot, tub, scroll, and wheels of that class were generally in use, with 16 to 33 per cent. duty.

Power in use: A race measurement showed 10,350 cubic feet water per minute, used with 3, of 5 grinders, operating without the electric wheel on, for a virtual fall of 16¼ feet or 320 horse power water, 240 "shaft;" full mill use would take about 400 horse power "shaft," plus 12·23 for light, the rated wheel power being 425.

Judge Peck's decree allots for the original head of 8½ ft. on Hill & Murray (increased by them to 17½), 20 horse power "per run" for wheels of 30 per cent. duty, or 4·152 cubic feet per minute, or for 7 runs 29·064 cubic feet per minute. For wheels of 75 per cent. duty now in use, this, at 16½ feet head, equals about 679 horse power.

Value: In the testimony on this point it was claimed that while water powers have no common "market value," in the sense of frequent advertisement of rates and transfers, and valuable powers were scarce, the actual value should be judged by the local conditions above named, and by the rates which have been paid at similar milling centers for similar power, as at Lowell, Cohoes, Holyoke, Paterson, Philadelphia, etc.

The old standard lease rate of Lowell, Lawrence, Cohoes, and Holyoke is practically about $20 per horse power "shaft" rent per year for mills usually running 10 to 11½ hours per day. At the "Belvidere," Lowell, from 1876, the time is limited to 10 hours; in these cases a low rate is asked to induce sales of land and population increase, the practical rent of Lowell being about $36.50 per horse power at the mills. The Essex, Lawrence, and other mills let rooms and power at $75 per horse power, room additional; 8 cents per square foot sometimes.

Mill Power Standards.—Lowell: Right to draw, during 15 hours in each day of 24, 25 cubic feet per second, at upper fall, when head and fall is 30 feet (low water 33 feet); 60·5 cubic feet on 13 feet middle fall (low water 14 feet); 45·5 cubic feet on 17 feet, lower fall (low water 19 feet); "shaft" power taken at 60 horse power.

Wamesit dam, Concord River: 27 cubic feet per second on fall 21·89 to 24·97 feet; average, 23½ feet; time limit, 11½ hours. Rate, 27 horse power; price, $2,750 rent.

Lawrence: 30 cubic feet per second, on 25 feet head and fall, limit 16 hours per day, varying with actual fall, less 1 foot. Ordinary summer fall, 28 to 29 feet.

Cohoes: Orifice, 50 inches by 3 inches, under 3 feet head and 17 feet fall, 6 cubic feet per second; rent, $200; about 4⅔ Lowell power; 3 falls of 20 feet, virtual.

Paterson: Orifice, 24 inches by 6 inches, 3 feet head and 19 feet fall, 8½ cubic feet per second, 21·19 horse power "water," 15·9 "shaft"; rent, $750, $47.18 per horse power "shaft"; 3 falls of 22 feet, virtual.

Manayunk, Pa.: 3 feet head and 18 feet fall, 24 hours, $6 per square inch; $56.25 per horse power "shaft."

Birmingham, Conn.: 1 square foot, 5 cubic feet per second, 12·5 horse power, 12 hours; rent, $250, $20 per horse power.

Dayton, O.: 15 inches head, 233⅓ cubic feet per minute, 1 run or power. 3 falls; 300 cubic feet per minute on 12 feet; 5·25 horse power "shaft"; rent, $200, $38 per horse power. On the "Lower race," for an actual use of about 64 horse power, $1,815 rents were paid, including structure; one tenant paid $550, using 10 horse power about ten hours. In our water-supply appropriations for cities, our notes show over $100 per horse power paid in various cases.

Rentals of steam power much exceed those of water; $2 and $3 per week are common rates; the Sears estate, Boston, gets $175 per year; at Lowell the lowest price is $100, and the Central Pacific mill, with 1,000 horse power, steam, prefers to pay $60 per horse power annual rate for extra water, for "months together," to running its engines (Sudbury River Case, p. 73). To substitute equal steam power, in another location, would cost $21,250 annually to Hill & Murray, or $425,000 capitalized at 5 per cent.

On the other hand, the proprietors of the Hydraulic Canal, having bought it for a small sum, to induce tenants, have made several very low leases; one has a sliding scale of $4 per 600 to 1,000 horse power up to $5.30 for 250 to 300; other leases are $5 and $10; but the supply is not fully maintained. A recent applicant has been charged $25, without guarantee; and I am retained in a case where power for additional machinery provided has been refused.

Mr. Herschel's testimony shows: Holyoke, power delivered by day, 15,000 horse power, night 8,000; about 70 tenants; investment about $3,000,000; population 30,000; day and night price, $40 per horse power, Hill & Murray power equal to 8 Holyoke mill powers each of 60 horse power "shaft," worth $30,000 each, or $240,000.

My valuation was for a minimum of 320 horse power "shaft," at $40, $12,800 rent, or $256,000 capital, at 5 per cent. Valuation of lands, $26,000; mill, $13,000; machinery, $30,000.

The State award was $81,690 for the entire claim, of which, it is said, the allowance for water power was based on 105 horse power at $10. This is another illustration of a curious experience in public works, under which men of the highest character, individually, when acting jointly sometimes seem to mutually disintegrate the plainest conclusions of duty to sufferers under the law of "eminent domain."

* A bench discrepancy at Albany, between the Coast Survey and United States Engineers, leaves this level in doubt; other checks make it nearly as given.

NEW GERMAN CRUISER.

The Charlotte, launched at Wilhelmshaven on September 5, is a frigate of 3,360 tons and 3,000 h. p. Length, 74 meters; breadth, 14 meters; draught of water amidships, 6 meters. She is divided into eight watertight compartments, built entirely of iron, has a double outer planking of wood, and is sheathed with copper. Her stern-post and rudder frame are of bronze. Her engines represent a new type in the German navy, with two compound engines with two cylinders, placed tandem fashion, operating the shaft or screw. The foremost of the engines may be thrown out of gear by means of a crutch, so as to be able, when steaming slowly, to work with the after engine alone. The two engines will act together only when going at full speed, which is estimated at 16 knots. Of the 18 15-centimeter guns with which the Charlotte will be armed, 14 will be placed in the covered battery, and four on the upper-deck in turret-like erections, called in German naval parlance "swallows' nests." A number of machine-guns and a torpedo-launching apparatus complete the armament of the new frigate. Her coal-storing capacity will suffice for 5,000 miles going at an average speed. The Charlotte was laid down in November, 1882, and has cost up to the present time, without armament and engines, about two million marks ($500,000).

THE FORTH BRIDGE.*

PROPOSED METHOD OF ERECTING THE MAIN STEEL PIERS AND APPROACH VIADUCTS.

By Andrew S. Biggart, C.E.

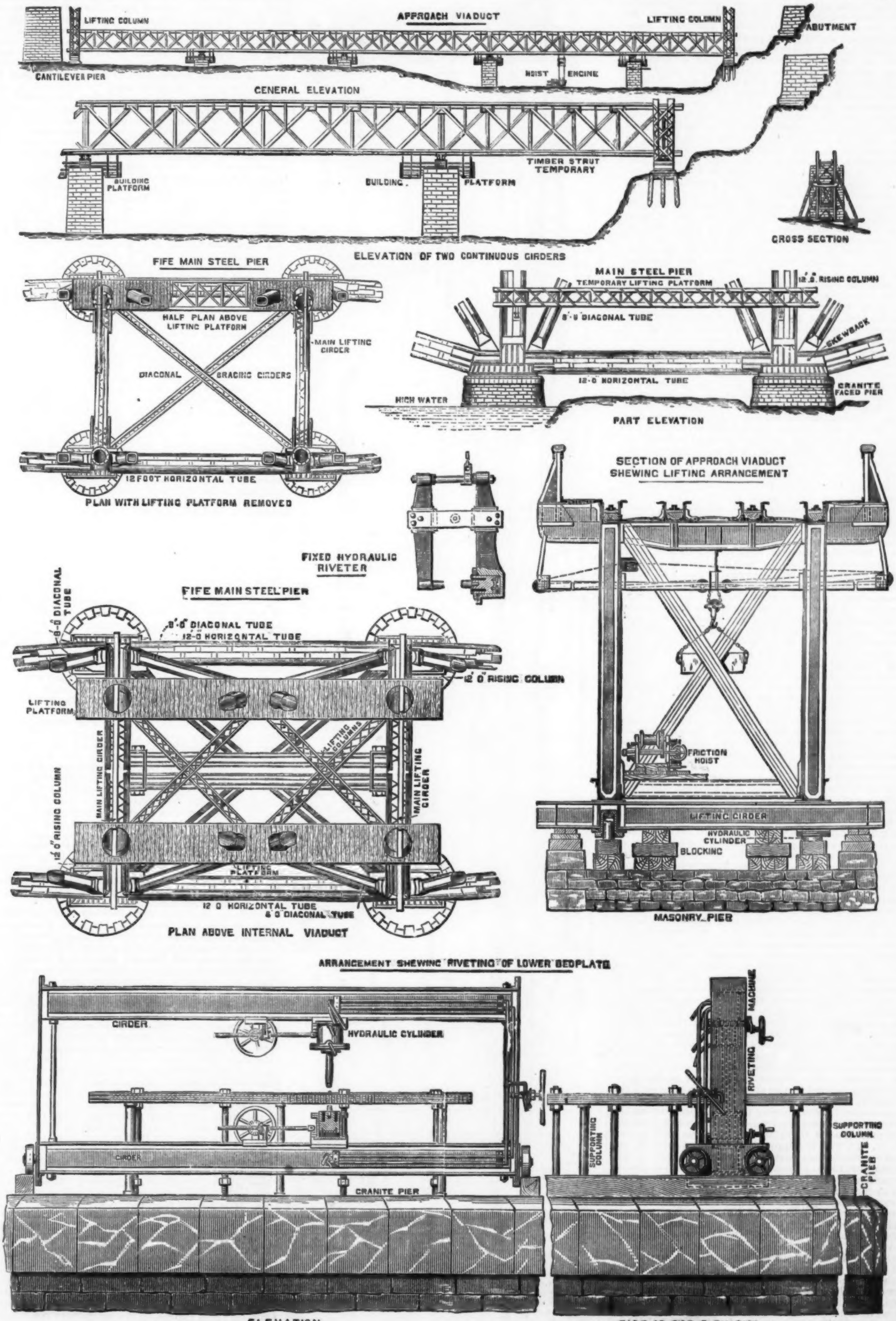
Works of exceptional magnitude, and more especially those in which the difficulties in the way of their accomplishment are in any degree proportionate to their size, must of necessity be of interest to this Association, constituted, as it is, to assist and in its own way act as a beacon to all in search of true knowledge. While the difficulties met with in preparing for and founding the piers of the Forth Bridge have been neither few nor unimportant, it is patent to even the uninitiated that causes for anxiety will neither disappear nor diminish till the erection of the steel superstructure has been completed. Presently our remarks will be confined to the main steel piers and approach viaducts. The term steel piers refers to those parts of the superstructure immediately over and between any of the three groups of four caissons. Described generally, each may be said to consist of two sloping and two vertical planes, the sloping including one connecting horizontal column and two 12 ft. rising columns, joined at the upper extremities by the top member, while from the lower end of each to the top of the opposite one there extends a diagonal 8 ft. tube. These two planes run parallel with the center line of the bridge, and are 120 ft. apart at the base and 33 ft. at the top. The vertical planes complete the structure at the ends of the two sloping planes. They consist of the 12 ft. rising columns already mentioned, with the lattice bracing joining these together. These members, with the internal viaduct and the bracing girders attached to the skewbacks, form the principal parts of the steel piers, the extreme height of which is fully 340 ft. above the bottom of the lower bed-plates.

The approach viaducts are, generally speaking, of ordinary design, with the exception of some special features to meet the unusual requirements demanded of them. The girders span a distance of 160 ft., and rest on granite-faced piers, rising to a height of 130 ft. above high water; the heights of these piers themselves gradually diminishing as they near the abutments, owing to the rising nature of the banks of the river. The magnitude of the main steel piers, both in respect of their great height and immense weight, demands that exceptional means be employed in their erection. Many proposals for effecting this have been suggested, and may be said to range from that of Mr. Arrol's first, which was to run up the columns independently, using them as the only staging, to that proposed by Mr. Baker, viz., to carry up simultaneously with the columns a rising platform, extending round the whole four columns, by utilizing them as supports, and upon this platform to carry up the top member, having the end junctions all previously riveted up, so that on arrival at the top, the final closing lengths of the 12 ft. rising columns had only to be joined to the junctions already fitted to complete this part of the work. After careful consideration, the weight requiring to be lifted was found to be too great, when compared with the advantages to be gained, to allow of its full adoption. In the case of the Fife and Queensferry piers, the weight was close on 1,200 tons, and several hundred tons more in that of Inch Garvie. A modification of this plan is that finally adopted by Mr. Arrol, with Sir John Fowler and Mr. Baker's full approval. The carrying up of the top member is done away with, but otherwise it is very similar. The engravings on next page illustrate the pier and this platform. The main lifting girders of the platform pass through the 12 ft. rising columns, and running in line with the vertical planes, extend from the one sloping plane to the other. Lying across these are placed other four girders, one being on either side of each set of 12 ft. rising columns, thus completing a rectangular platform resting indirectly on the main rising columns. The weight of this platform, including the necessary cranes and other plant required during the erection of the higher parts of the pier, will be about 400 tons.

The first part of the superstructure is that termed the lower bed-plate. Several of these are now completed and in position. They are made up of a series

* British Association, Aberdeen. Illustrations from the *Engineer*.

of longitudinal and transverse plates securely riveted together, and run about 37 ft. long by 17 ft. 8 in. wide, with a thickness of from 3 in. to 4 in., as seen in the engravings of lower part of this page. The whole plate is bolted on a number of short iron columns *in situ*, and is riveted up by a special hydraulic machine. Two girders are employed, one above and the other below the bed-plate, and extending beyond it are there joined together. On each of these girders slides a hydraulic cylinder, one having a little more effective area than the other, while both are regulated by the same cock. The result is that when water is admitted the total pressure on one cylinder is greater than that on the other, thereby holding the rivet head firmly in place while the point is being pressed up. The work thus produced is of the very highest quality. Since the whole machine moves lengthwise and the cylinders slide crosswise, the full surface of the plate is commanded by it. The riveting is also done expeditiously, the machine being capable in ordinary work of closing during a single shift 600 1⅛ in. countersunk rivets. When finished, the bed-plate is finally lowered into position. The upper bed-plate, or base on which the various connections at the foot of the rising column

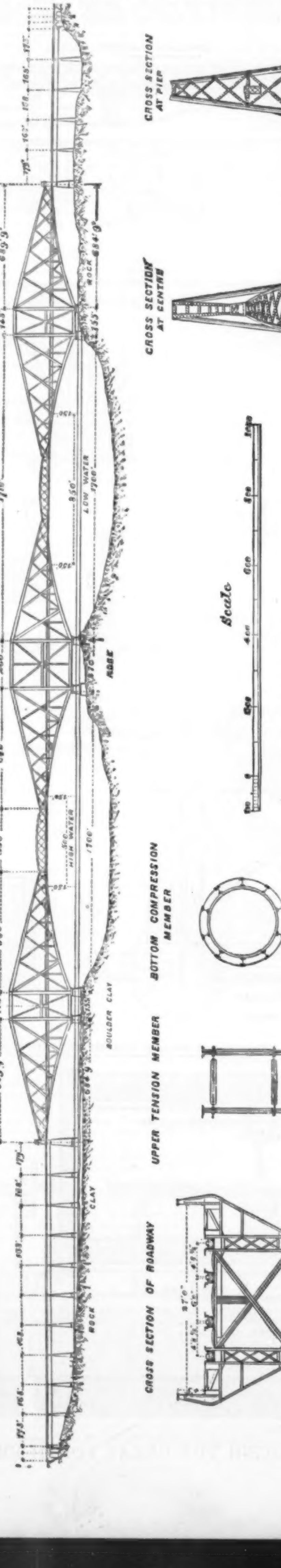


ERECTING THE GREAT FORTH BRIDGE.

rest—and which collectively constitute what is termed the skewback—is proposed to be riveted in a like manner to the lower bed-plate. While being riveted it will be secured to heavy steel girders, instead of columns, as in the case of the lower bed-plate, to keep it in true form. After lowering the upper bed-plate into position, the diaphragms and various other parts will then be built on it, and riveted up by common hydraulic machines, as well as by the special hydraulic machines designed by Mr. Arrol for the purpose. As many of the spaces in which riveting has to be done are very confined and difficult of access, high pressures will be used with machines correspondingly small; thus while the ordinary pressure will still be 1,000 lb. per square inch, it will be increased in some cases to as high as three tons per square inch by a simple pressure multiplier wrought by the ordinary 1,000 lb. pressure. This low pressure is admitted to the large end of the compressing ram, the smaller end of which produces the increased pressure—proportional to the difference in areas—required to close up the rivet properly. The riveting machine is very small, each cylinder weighing about half a hundred weight. The smallest proposed cylinder is only 4 in. diameter, is of the simplest form, and contains a hollow plunger provided with a single cup leather at the inner end. A spring is secured to the plunger and back end of the cylinder for the purpose of drawing back the plunger when the exhaust water is allowed to escape. When in place and at work, the machine will be hung to the one end of a small wire passing over a pulley, while at the other will be fixed a balance weight to relieve the operator of the weight of the machine. Two cylinders, one outside and one inside, will be required at the closing up of the rivets; both will be connected to the compressor, and wrought by it. The horizontal tubes, skewbacks, and lower parts of all the columns will be built by ordinary cranes till they attain a height of about 30 ft. above the bed-plates. At this point of the 12 ft. rising columns will then be commenced the longitudinal channels—through which are drilled the holes for the steel pins to pass through them and the cross girders; to these channels the cross girders will now be attached within the column, on the higher of which will be laid the two main lifting-girders of the platform. Extending between and beyond these, but at right angles, will be the other girders required to complete the rectangular platform already referred to. The principal work above this will be executed from this platform, as it is being raised toward the top of the pier. In that work will be included the 12 ft. rising or supporting columns, the 8 ft. diagonal columns, and the bracing in the sloping planes. The vertical planes will be built similarly as the platform is raised upward. When all is ready to be raised for the first time, the positions of the various members in the pier will be somewhat as follows: The four rising 12 ft. columns will have the whole of their channels, and eight of the ten plates in section, in each column at a convenient working height above the platform. The other two plates require to be kept off at this point to allow the main lifting girders to pass through the columns, and can only be placed in final position from underneath the main lifting girders. The columns will only be bolted together at this point, but as few more bolts will be required than those necessary to make good work when riveting up, very little labor will be lost. The 8 ft. diagonal tubes in the sloping planes will also be carried up above the level of the platform. They pass between the girders and lie in the sloping planes, and will be wholly riveted up above the level of the platform. The bracing in the vertical planes being 12 ft. wide allows the main lifting girders to pass through it, and will be built to a large extent from a platform on the top of these girders, only the top and bottom bracing requiring to be placed and riveted in position underneath the main lifting girders. While the whole of the tubes will be built in single pieces, in the case of the bracing girders, it is intended to take up and fix in position sections of a size convenient for handling with dispatch under the somewhat novel circumstances around.

The riveting machines employed will be of various forms, the common type being used for such work as the bracing girders, while those for the rising and horizontal columns will be the same in principle as those riveters employed for the bed-plates, with several special features to suit the different kind of work. The girders on which the cylinders slide will be similar and similarly placed in relation to the work to be done, one being outside the column and the other inside, while at the ends they are secured to and made to slide round two circular rings by a small hydraulic cylinder. Stiffening packings or struts are placed between these circular rings, and the channels of the columns inside, and plates outside to keep all in true form, and these are transferred from one point to another as the girders pass the various positions at which they are placed. The girders are thus made to move round the complete circle, and as the hydraulic cylinders on these slide a length of 16 ft., it follows that the riveting done at each shifting of the machine is equal to this length of the completed column. To enable the riveting to be executed with the longitudinal built-up channels complete, the power of the hydraulic cylinder on the inner girder is transmitted to the rivet through a lever of the third order, this cylinder having the amount of greater area necessary to exert nearly the same pressure as the cylinder on the outer girder. It is proposed that the whole machine be fixed to the platform and underneath it. It will consequently be raised with it, but during the stationary periods between the lifts it will rivet up the 12 ft. rising columns close to but always underneath the main lifting girders. Each machine is made to carry its own working platform, from which all the necessary operations will be conducted.

The raising of the main platform by the hydraulic cylinders placed within the 12 ft. rising columns will be perfosmed thus: Water will first be admitted to the lower end of two of the hydraulic cylinders, in one or other of the sloping planes, sufficient to ease the main lifting girders and the two upper cross girders within the columns. The pins through these cross girders and the channels of the columns being withdrawn, water is again admitted, and made to raise the one end of both main lifting girders 1 ft.; when this is accomplished, the same pins are inserted and the load again transferred to the cross girders. The water in the lower end of the cylinders now being allowed to escape, that in the small annular space at the other end, and which is constantly acting as a back pressure, raises the cylinders, and with them the lower cross girders, to the same position, relative to the upper girders, which they occupied before the lifting operations began. As the pin holes in the four lifting channels run the full height, the point to which the platform may be lifted at any one shift is a matter of expediency. This lift in most cases will be about 16 ft., but in any case it will be effected by single lifts of 1 ft. at a time, as already described. It will be apparent that the matter of lifting at the different points in each platform is exactly similar, the cylinders being in line with the 12 ft. rising columns, and made to raise the platform, to all intents, vertically, induces a slight rocking motion, which is provided for in the cylinders by planing their bottom surfaces to a very obtuse angle, the apex of which is slightly rounded off to form a better bearing. As the platform is raised, the girders in line with the sloping planes will be slid toward the center of the bridge, each pair on either side being always kept as near as practicable at an equal distance from the center of the rising columns.



THE BRIDGE OVER THE FORTH.

The raising and riveting will thus be carried on till the whole arrives at the top of the pier, the platform being then in a convenient position on which to build the top members extending between the columns in line with the bridge. These will now be built, and with them the top junctions or connecting portions of the upper part of the steel pier, resembling in many respects the lower junctions termed the skewbacks. All will be riveted in position by the machines already referred to. After the main platform has passed the point at which the internal viaduct is joined to and made to form an integral portion of the bracing in the vertical plane, the lifting of the girders, etc., of which this part is composed and previously riveted complete, to its position will then be commenced. This will be done by means of four complete sets of columns, girders, and hydraulic cylinders. The cylinders will be placed within and fixed to the upper of two cross girders, sliding on and temporarily bolted to the two vertical columns at each corner of the part to be raised. Passing between and extending across from one set of columns to the other will be the carrying girders, resting on the top of the upper cross girders, and bearing the portion to be lifted into position. The ram will be made to point downward, and bear against the top of the lower cross girder. When water is admitted to the upper end of the cylinders, the bolts in the higher cross girders meanwhile having been withdrawn, the rams are forced against the lower cross girders; but as these are securely fixed to the columns, the hydraulic cylinders, with the cross girders, carrying girders, and structure to be raised, are bodily lifted upward. When raised about one foot, the upper cross girders are again fixed to the columns and made to carry the load. The water is now allowed to escape, and as there is a back pressure in the cylinders similar to that in those used for raising the main platform, the rams are forced into the cylinders, and being secured to the lower cross girders are made to raise these also. This action will be repeated till all is raised to the desired height, when the girders will be quickly secured to the points previously prepared for their junction with the bracing in the vertical planes. In addition to the several parts of the bridge already mentioned, the cantilevers will form a leading subject for careful thought. The proposed method of their erection is, however, beyond the scope of this paper, and we need only to remark that all concerned see their way to successfully overcome this part of the work also. The approach viaducts on both sides of the Firth are presently in a forward state of progress. The girders on the south side, immediately over the water, being practically complete, having been built on timber staging, the top of which was on a level with the stone piers, so far as completed, or about 18 feet above high water. These girders will be raised to the level of the next stage, erected on shore, on which will have been built, during the time occupied in that lifting, another pair of girders to which the first portion of the viaduct will be connected. This raising and joining to other portions, still higher up, will be continued till the full height is reached, when all the ten spans will be complete. The north viaduct is in a more forward state than the south, it being wholly completed, with the exception of a few of the end bays, which cannot be put in position till a higher point has been reached. The whole of the north viaduct piers are on land of a very undulating character. This necessitated some of their number being raised a considerable height, so that a uniform level throughout might be attained, and all the girders built at the same time on a stage similar to that used for the other side. The piers provide points from which the lifting can be easily and safely done.

Various proposals for effecting this were discussed; that finally sanctioned by Sir John Fowler and Mr. Baker is to place underneath the end pillars of the main girders on each pier a temporary cross girder extending between and beyond these, and bearing up the whole weight, on timber blocking, resting directly on the pier. In each of these temporary cross girders are placed two hydraulic cylinders, one being directly underneath each main girder. In both, the ram faces downward. Each cylinder is provided with a separate valve, to regulate its action in raising. When at rest, the temporary cross girders will transmit their load to the piers, either through the blocks placed close to but between the lifting cylinders, or those outside and nearer the ends of the piers, this being determined by the point at which building has to be carried on. If in the center, then the supports are outside, and *vice versa*. The ram, when lifting, will bear on a prepared sole of hard wood spreading somewhat over the stonework. Great care must be exercised to keep the different bearings in the whole viaduct as near one uniform level as possible during the lifting operations, to avoid any undue straining of the main girders. As soon as the structure has been raised the full stroke of the cylinders, a new lift will be commenced, the blocks on which the rams bear having, however, been previously packed up. The height required to give ample clearance for building underneath will be about four feet. At the ends of the north viaduct, in lieu of a bearing on the piers, columns, with all the other appliances, have been provided, similar to those to be adopted for lifting the internal viaduct already described. A hoist is provided for lifting from the ground underneath the main girders the whole of the stone, etc., required in building the piers upward from their present level. This material will be raised while on trollies, and while still on these run along the temporary road, laid on the bottom of the main girders, to any or all of the piers. On arrival at any pier, it can be raised and laid in position by a pair of small runners fixed to the girders im-

mediately above each pier, the power used for raising, lowering, or traversing either way being transmitted through special horizontal winches driven by a rope extending well-nigh the entire length of the viaduct. The work will thus be carried on till the desired end is attained, that being reached when the rail level is fully 150 feet above high water.

Were we to state that these are the exact methods by which those parts of the bridge presently treated of will be erected, we should only be laying ourselves open to the ridicule of all experienced engineers, as it is a well-known fact that no undertaking of such a magnitude is ever carried out to the letter of the plans originally decided upon. The foregoing are only presented as the results arrived at after full discussion by all concerned, and as the principles on which the full details will be wrought out as the work proceeds. Thus far all has gone well, no difficulty having arisen which can be said to have taxed the latent ability of either the engineers or contractors; and, judging the future from the past, there is every reason to conclude that in the near future the successful erection and completion of the Forth Bridge will be a matter of history.

[THE MILLER.]

POWER LOST BY FRICTION IN THE BEARINGS OF ROLLER MILLS.

IN a report on Hungarian roller mills, Otto Muller states that from 2·7 to 5·2 cwt. of wheat are being ground per indicated horse power for every twenty-four hours, while statistics show that they used to grind on their stones 3·15 cwt. per indicated horse power during the same time. This statement shows that, compared with stone mills, a great saving of power is gained in some of the roller mills, while in others it is not. In the most favorable case they are doing 75·6 per cent. more with rollers than with stones with the same power and in the same time, while in the worst case they are doing 14·3 per cent. less. This shows that power is not saved in the working of a roller mill unless it is fitted up with well designed machinery.

As most of the power in a roller plant is required for the reduction of the wheat and middlings, it is of the greatest importance to have well designed roller mills. I give below a simple rule to enable every miller to calculate for himself what horse power he loses through friction on the bearings of every roller mill. I will, for example, take one of Mr. J. Harrison Carter's four roller break mills with four rolls each, 25 in. long and 9 in. diameter. This machine, when fed up to its fullest capacity, will take about 100 grains over its whole length of 25 in., and that gives for one revolution (the circumference of the roll being 28·27 in.) 22,608 grains, which weigh about 0·1826 lb., consequently one pair of rolls running (take the average speed between 125 and 300 revolutions) 212 revolutions will grind 24·75 tons of wheat per day of twenty-four hours, and therefore the two pairs of rolls will grind very nearly 50 tons. Professor Kick, in his work on "Mehlfabrikation," says that it requires about 18 lb. pressure or weight to break open one grain of wheat, and the rolls, for a fair average feed, have to be pressed together with a continuous pressure of 900 lb. during the operation of breaking the wheat.

The loss of power from this machine will be easily found by the following rule:

$$R = 4.c\,\frac{P.\pi.d.r.}{29{,}400}$$

where

R is the horse power lost through friction on the bearings.

P is the pressure required for the breaking of the wheat, viz., 900 lb.

d is the diameter of the spindle in the bearing in feet = 0·187.

r revolutions per minute = 212.

c coefficient of friction = 0·054.

This very low coefficient of friction can only be used for very perfect and continuously lubricated bearings; for ordinary bearings, 0·075 must be used as a coefficient.

$$R = 4 \times 0{\cdot}054\,\frac{900 \times 3{\cdot}141 \times 0{\cdot}187 \times 212}{29{,}400}$$

$$= 0{\cdot}216\,\frac{112033{\cdot}52}{29{,}400}$$

$$= 0{\cdot}216 \times 3{\cdot}81$$

= 0·82296 horse power for one pair of rolls, and for the two pairs of rolls the total loss through friction on the bearings will be 1·64592 horse power. In smooth roller mills for treating middlings the loss of power will be greater, as a greater pressure is required to reduce middlings and semolina.

From experiments made by myself, I find that some average middlings to be crushed sufficiently between rolls 25 in. long required a pressure of 1,200 lb.; and in order to reckon the power lost by these machines, we shall have to change P in the former example from 900 to 1,200 lb., and also change the speed from 212 to 200 revolutions.

$$R = 4 \times 0{\cdot}054\,\frac{1200 \times 3{\cdot}141 \times 0{\cdot}187 \times 200}{29{,}400}$$

$$= 0{\cdot}216\,\frac{1409{\cdot}20}{29{,}400}$$

$$= 0{\cdot}216 \times 5{\cdot}13$$

= 1·10808 horse power,

and for the double machine 2·21616 is the horse power lost by friction in the bearings of the smooth four roller mill. Professor Kick gives some calculations for the same thing on Wegmann, Ganz, Haggenmacher, and other Continental smooth roller mills for reducing middlings, and he gets from 1·23 to 6 horse power on four roller mills with the rolls not more than 25 inches long.

This loss of power, as given above, is for bearings in good condition and well lubricated, and it is to the miller's advantage to see that the bearings are in proper condition, so as not to increase this loss. As I said in the first part of this article, in comparison with millstone mills it is not only the roller system generally that has the advantage of saving power, but it depends entirely on the sort of machines and especially well designed roller mills, as the roller mills in a complete roller plant take about two-thirds of the whole power required for the plant to turn out satisfactory or not.

G. F. ZIMMER.

ORNAMENTED WARDROBE.

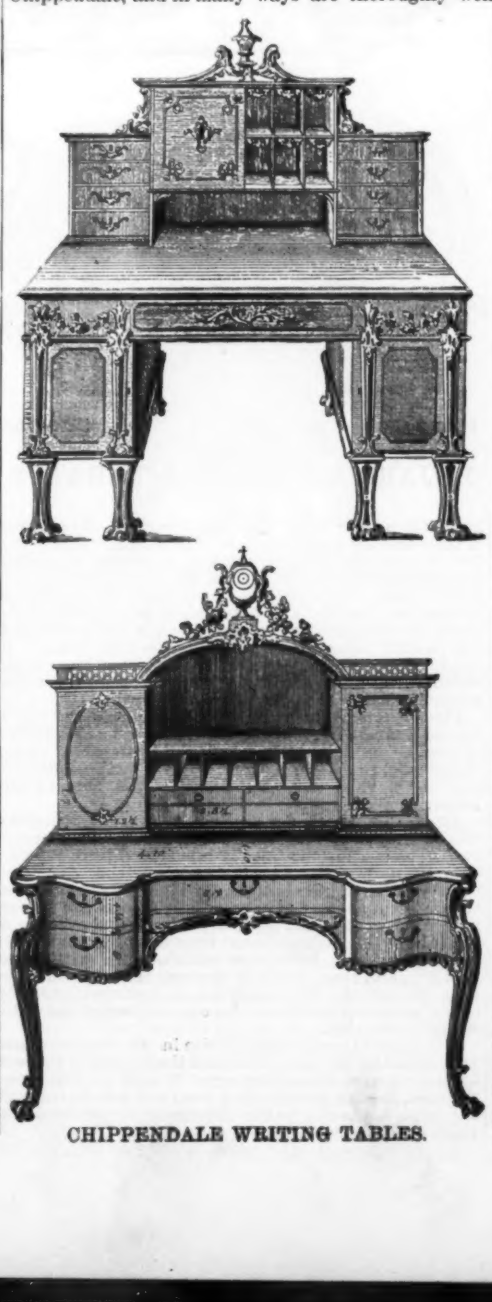
THIS wardrobe was designed by Boule in the seventeenth century. It is profusely sculptured and inlaid,

ORNAMENTED WARDROBE.

in some places with helmets, swords, and battleaxes, as was then generally done by carvers of that period, no doubt copies of the celebrated examples which had been set them by Jean Gougon.—*Building News.*

CHIPPENDALE WRITING TABLES.

BOTH these admirable writing tables are typical of Chippendale, and in many ways are thoroughly well



CHIPPENDALE WRITING TABLES.

adapted to modern uses, for which they are, of course, intended. Pigeon holes and little nests of drawers go to furnish the interior parts, the designs being here shown by Chippendale's own illustrations of them, giving figured dimensions, which are useful for reference. The queer perspective in the drawing of the left hand table need scarcely be pointed out; but the detail of the carving and the several mouldings are very clearly put in.—*Building News.*

RELATIVE DURABILITY OF SIMPLE AND COMPOUND PAINTS.*

Question.—"Is a car body color composed of one durable pigment more durable than a color composed of two or more pigments?"

This question which has been assigned to me to open is a vital one, especially so as there is here in the East—I do not know how it is in the West—quite a craze to adopt a dark color; and in the composition of that color some whose authority it is to adopt a certain color remind me of the saying of my aged grandfather, who was fond of that pioneer New England dish, "pudding and milk," and who insisted on putting in his piece of apple pie with it and eating it all together, remarking when remonstrated with: "The more good things, the better." There seems to have existed in the dreamy eyes of some president of some railroad or other high official, a certain unheard of and unnamable dark color, which the painter is expected to produce by the admixture of a little of this and a little more of that, or something else—no matter what, as long as the color to suit is obtained; and when it is at last reached, it is declared to be the thing, and it is rushed on to the cars regardless of time or expense. And after a lot of cars have been done over, it is remarked by the simple-minded, "How much better they look!" Of course they look better, because so many have been newly painted, and they are uniform and all shine together; but time—that inexorable judge—will render his own verdict, as he has done heretofore in the case of a new error which has seemed to be better than an old truth.

In opening this question, however, I do not appear in the *role* of a judge, but rather of an advocate, contending simply for my opinion, briefly touching a few salient points; and if I can offer that which will touch your thought-springs and set you all to presenting your opinions—all to be candidly received and considered—I shall be satisfied. It seems to me, however, without wishing to appear egotistical, that there can be but one decision which you will all reach sooner or later, and that is: A car body color composed of one durable pigment will last the longest. True, it is a matter which the knowledge of chemistry must decide; and such a knowledge, obtained from theoretical study, few of us have; but a practical experience has given us a sprinkling of this knowledge, which serves as a light by which we can cautiously make our way, if we do not start off with the strides that we might, were we analytical chemists. There seems to be some analogous reasoning which might be introduced here, drawn from a little medical information. The time used to be when the old doctors thought that the more good things they got together in a recipe or prescription for a sick man, the sooner he would be cured, little thinking of the result of the chemical action which these drugs might exert upon one another, which later thought has discovered. And now it is considered the height of medical skill to cure a disease with one specific drug, which is commonly done. Need I say that it is the height of the painter's skill to obtain his color with one pigment if possible; but if not, with the fewest number, for the same reason? It is said that an old doctor used to put all the odd bits of medicine, which he had left in treating cases, into a jug, and used to tell his student that if he could not cure his patient with anything else, he gave them a dose out of the jug! And I think it would be well for the painters on some railroads that I know of to have a jug into which they could put their odd bits of paint; and then when they get a case of "touching up" that they cannot match with anything else—and they are liable to have them frequently with such a compound as their color is made of—they can give it a dose from the jug! Again, a man of means with an æsthetic eye might desire to overdo his neighbor, and put into his artificial fishpond all kinds of fish, great and small, an almost endless variety; but he would soon discover that the big fish had eaten the little ones all up.

And it is precisely so with paint; the most durable pigment—the one which is good enough to be used alone—is put with others of a weaker nature, and a prettier color, to be sure, is obtained on the start; but in a short time it is discovered that the weaker colors in the compound have been eaten up by the stronger, and the result is a new color entirely. I have a case in point. I know an old painter who painted his own house several years ago, a beautiful gray, composed of white, Indian red, and Prussian blue; the result was in a few years he had a pink colored house, the Indian red having eaten up the blue almost entirely. In fact, it seems to be a principle running through all nature that too much mixing and compounding of things together is dangerous or unwise, to say the least. The food we eat would tend to the durability of our health better if partaken of more in simplicity, one kind at a time, or a very few kinds at least; and the drink—what intemperate man does not know the grief that comes from "mixed drinks"? What is better after all than pure water? But it is no doubt true that there can be a union of two pigments which would make a more durable paint than either one of those pigments would alone, the same as the crossing of species in animal or vegetable nature sometimes turns out a stronger and better kind than either of the two alone which entered into the union. It is an old saying, you know, that "in union there is strength," but it makes a difference what the union is composed of, what the nature of the component parts. And yet this does not argue but that there may be a single pigment which is more durable than ten others which you may put together. In fact, I think that lampblack, the most durable pigment known to chemistry, and Indian red or some other mineral, used alone will outwear any combinations which may be made. But the compounding of pigments

* Paper read at the recent convention of the Master Car-Painters' Association by Charles E. Copp, Master Painter of the Boston & Maine Railroad.

into paint is all a matter of chemistry, which alone must settle what will do to become united to produce an unfading compound. However, past experience does not show that theoretical chemistry has given us anything to brag of; it has come to us rather by the hard knocks, hopes, doubts and fears of a personal experience at the work, which perhaps is the only way painters can ever get a knowledge of chemistry which applies to their business—a way that is well enough to get wit; as the old adage has it, "Bought wit is better than taught wit, if you don't buy it too dear." One thing seems certain, those who are fortunate enough to get a good education and become thorough in chemistry consider themselves too fortunate to become practical painters, and those who are perhaps unfortunate enough to have to paint for a living seldom have the time or means to procure a theoretical knowledge of chemistry, *i. e.*, from books. Therefore, if I were the railroad official who disliked the color of my cars, and wished to change it (that task is in no danger of falling into my hands, because I am the painter), I would look into nature first to see what I could find for a color. No, I would not; I would confer with my painter and yield to his judgment, if I had one good for anything; and if I had not, I would get one. Then, if I were thus empowered by the master car-builder, or whosoever I was under, to see what I could find for a color, I would, as I said before, look into nature first—into the mineral world—to see what she had for me for a single item to make a paint out of; then, if she had not what I wanted, I would consult chemistry to find that which used singly, or at most by a union of two, would produce what I wanted. I would do all this before I had decided upon a color, and went scouring around among pots and pails to see what would make it, which is most always the case, I am sorry to say. The cart has got to going too much before the horse; color first, and what it is made of secondarily. But we can afford to forego a little beauty of color when new to get something that is abiding. Let us look around in nature and in chemistry to see what will be an abiding color to use first, and then consider its beauty secondarily. What looks worse than a streaked, faded, dingy color which has enough of it left to remind you of its former beauty? Who can point the finger of scorn to a quiet, somber, plain, quakerish-looking paint, made perhaps of one mineral, or lead added, modestly decorated, that holds its own well down to the burning-off time? This is a great age of talked-of uniformity in the appearance of rolling stock upon railroads, but I submit that the end never will be reached till more common sense enters into the selection of a body color for passenger cars. And here let me say that I do not set myself up as having attained to perfection in the matter. I have really given the subject more thought than actual experience, for the color of the passenger cars on my road—made of white lead and stone yellow, which has been in use ever since the road started, for aught I know, and gives good satisfaction—seems to be a fixed matter; and I do not at present know of a better choice to make were I to try, as I am in favor of a light color so far. Yet I have no doubt there is a single mineral or chemical production which would excel in many respects. But I had been thinking over this matter for years previous to the letter of request desiring me to take it, hence I throw out these hints for you to think and discuss at length, hoping that good may be elicited therefrom.

APPARATUS FOR THE MANUFACTURE OF BEET SUGAR.

THE extraction of sugar from beets necessitates a series of operations that may be briefly enumerated as follows: (1) Washing the beets; (2) rasping; (3) extraction of the juice; (4) defecation; (5) concentration and filtration; (6) boiling the sirup; (7) draining and turbining. Finally, the residua from the turbining, that is to say, the molasses, are treated by various processes.

The apparatus of Mr. Dujardin, which we illustrate herewith, are applied in the operations 5 and 6 just mentioned.

Evaporating Apparatus with Central Injection. (Figs. 1 and 2).—The three cases of which the apparatus consists are arranged in the same manner, but their diameter increases from 5 feet, which is that of the first, to 6, which is that of the third. The diameter of the middle one is 5¾ feet.

Each case is formed of two cast iron cylinders, A and B, provided with flanges and inclosed in a mahogany jacket. The first cylinder, whose height is 4¼ feet, is closed by two brass disks, *a* and *b*, which are united by tubes of the same metal, 2 inches in diameter and 0·08 inch thick. These tubes are so arranged as to leave a free space in the center through which the steam is directly led by the central pipe, C, the internal diameter of which is 11 inches, and which traverses the disk, *b*, through a stuffing box, so as to permit it to expand freely. The total number of tubes is 420 in the first case, 506 in the second, and 606 in the third, corresponding to heating surfaces equal, respectively, to 870, 978, and 1,198 square feet. The upper part, B, of each case is bolted to the lower part, A. Its height, which is 8 feet, is prolonged by a cylinder, E, of smaller diameter, surmounted by a steam dome, D. This latter is cast with an elbow to which, and to the central pipe, C, is bolted the pipe, *f*. The bottoms, G, G^1, and G^2, of the three cases connect directly with each other through the parallel pipes, *g* and *g'*. Moreover, the bottom of the first communicates with the part, B^1, of the second through the pipe, h^1, between the bottom, G^1, of the second case and the part, B^2, of the third.

Finally, a large cast iron pipe, *k*, connects the valve-boxes, K and K^1, that are bolted to the sides of the domes, D^1 and D^2, of the second and third cases. As for the pipe, *f*, that does not end directly in the dome, D^1, but in a valve-box, F^1, fixed to the side of the latter.

After this short description, it is easy to see the course that the steam and juice take in the apparatus. The saccharine juice is introduced into the first case through the cock, H, traverses the collection of tubes, and fills the bottom, G. The waste steam from the different engines of the works is collected in a reservoir, from whence the pipe, C, leads it to the center of the tubes. The tubes nearest the center become highly heated, and the juice rises within them with great rapidity, and then descends through the tubes farthest from the center. The result is a continuous circulation of the juice that facilitates the evaporation of the water which it contains.

The vapors thus produced rise in the first case, and are carried by the pipe, *f*, around the system of tubes of the second case, where they serve to heat the juice from the case, B—this juice having been led into B' through the pipe, *h*, thanks to the difference in pressure that exists in these two cases.

The juice contained in the case emits vapors, and these, led by the pipe, *f'*, around the system of tubes of the third case, heat in turn the juice that has been introduced into it by the pipe, *h'*. A simple maneuver of the cock, H^2, again permits of such introduction, because of the difference in pressure existing between the two last cases. The juice thus concentrated makes its exit through the bottom, from whence a cock, N^2, gives its access to the pipe, *g*, which leads it to the copper boiler to be described hereafter. The cocks, N and N', remain closed, as do also Q, Q', and Q^2.

It is this same decrease in pressure that causes the non-condensable gases and the excess of steam not condensed in the tubes to pass from the first case into the second, and from thence into the third. This gas and steam is collected by vertical pipes, I, placed along the sides and connected with the semicular tube, *i*, which communicates, through the pipe, J, with the following system of tubes. The cock, *j*, permits of interrupting the communication.

The water condensed in the system of tubes passes in the same way successively from the first to the second, and then to the third, giving rise in doing so to a quantity of steam which is proportional to the difference in pressure. The pipes, *l* and *l'*, of these waters of condensation end in reservoirs cast in a piece with the disks, *a* and *a'*.

The safety vessels here consist of the domes, D, and the annular crowns, E. The pipes, *d*, lead into the cases all the liquid that may have been carried along through the evaporation.

A circular gutter, *e*, cast in a piece with the upper part of each chest, and a collar, *v*, fixed at the same height to the central pipe, prevent the juice from running over the sides.

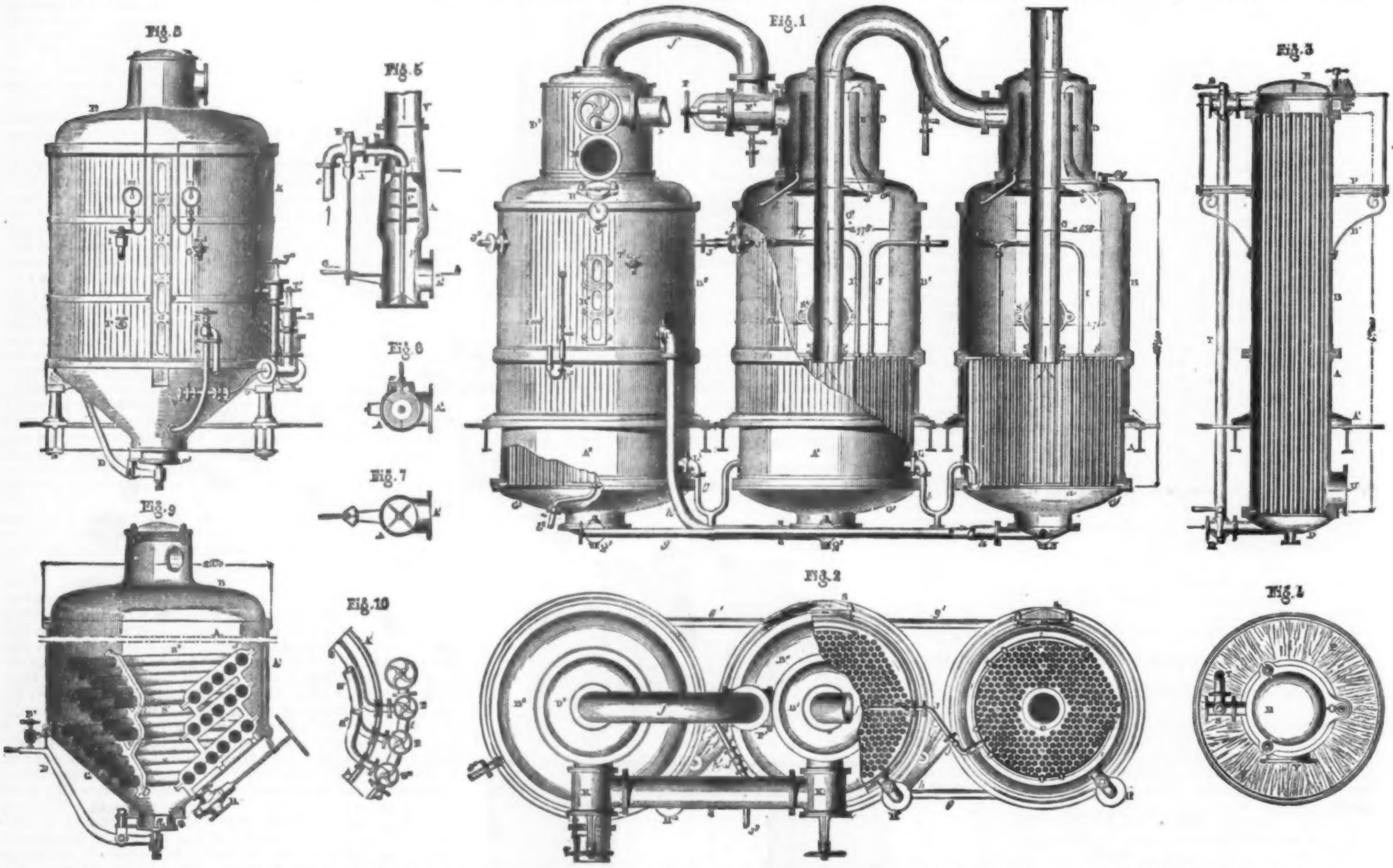
The central injection of steam that characterizes this apparatus permits of giving the conduits in which it circulates a wide section. Moreover, these conduits present but a few abrupt bends, and thus differ from those in most apparatus of the kind, where the steam is often submitted to frequent changes of direction.

In order to change the triple action of the apparatus to a double one, when it is desired to clean the last chest, the valves, F' and K', are closed, and the valve, K, is opened, the result of which is that the last chest is isolated from the second, and that the dome of the latter is made to communicate, through the pipe, *k*, with the escape-pipe, M. The cock, *j*, too, should be turned in such a way as to shut off communication between the tubes, J' and *i*, and to establish one between *i* and the tube, J^2. Finally, the cocks, L' and N^2, should be closed, and the cock, N', be opened.

The arrangement of the pipes, *g* and *g'*, with cocks, N and Q, at the bottom of the chests permits of emptying any one of the latter in case of accident.

The apparatus is provided with pressure gauges, *m*; glazed sight-holes, R; butter-cocks, T, that permit of introducing grease* or air at will; and with man-holes, S, that permit of access to the interior for the purpose of cleaning the tubes.

The Condenso-Heater (Figs. 3 and 4).—This apparatus serves to heat the raw juice, while at the same time condensing a portion of the steam that issues from the preceding apparatus on its way to the condenser. It consists of a cast iron cylinder two and a half feet in external diameter, one inch thick, and thirteen feet in height. It is formed of three sections, the smallest of



FIGS. 1 and 2.—Triple-acting Evaporator. (Scale 1-40). FIGS. 3 and 4.—Condenso-Heater. (Scale 1-40). FIGS. 5 to 7.—Injector. (Scale 1-40). FIGS. 8 to 10.—Granulating Boiler. (Scale 1-40).

DUJARDIN'S SUGAR APPARATUS.

* This is introduced for the purpose of causing foam to subside.

which, A, is cast in a piece with a concentric shoulder, A', through which the apparatus rests upon the floor. Around the second are fixed brackets, B', which support a platform, P.

In the interior of the cylinder are arranged fifty iron tubes, c, of 2¼ inches external diameter, and ⅛ inch thickness. The lower part is closed by a stationary bottom, D, and the upper by a cover, E. This latter, which is pivoted, has a regulating screw and self-closing bolts to permit of its quick opening every time the tubes, c, need to be cleaned. Two three-way cocks, R and S, are affixed to the extremities of the cylinder, and are connected by the pipe, T. The juice to be heated enters through the lower cock, R, passes into the tubes, and makes its exit at the top through the cock, S. The steam enters through the elbow, V, seen in plan in Fig. 4, circulates around the tubes, c, and makes its exit at the base through the elbow, U, along with the water of condensation, and goes to the injector.

The Injector (Figs. 5 to 7).—The injector, which is wholly new, is shown in vertical section in Fig. 5, and in horizontal section in Figs. 6 and 7. It is designed to condense the steam produced in the boiler or in the evaporating apparatus.

The steam is led to the top of the apparatus by the pipe, V, as is also the water by the pipe, e, to which is fixed a regulating cock, E. The water falling upon the disks, P, condenses the steam with which it is in contact as far as to the bottom of the apparatus, whence it makes its exit through the elbow and goes to the air-pump. An aperture, a, at the side permits of cleaning the upper disks, which are the ones that become most quickly incrusted. This injector has the advantage that it brings the cold water into contact with the steam throughout the whole extent of the apparatus. This is a feature not found in the ordinary injectors in use.

The Boiler for Granulating (Figs. 8 and 9).—The closed boiler shown in Figs. 8 and 9 is especially designed for producing sugar in coarse grains. As well known, in order to obtain sugar in large crystals, it is necessary to form in the first place but as small a number of grains as possible, in order that the sugar contained in the sirup supplied to the boiler until it is full may build up but a small number of grains, which, consequently, will become coarser than if the same quantity of sugar had to distribute itself among a large number of grains.

In order to form the first crystals, only the smallest quantity of syrup possible must be admitted to the boiler.

Mr. Dujardin's boiler consists of an iron plate cylinder, A, 7 feet in internal diameter and 7½ feet in height. The bottom, C, is of cast iron (as is also the top, B), and is closed by a cap, d, which is held against its seat, C', by a lever, D. The boiler is inclosed in a wooden jacket, A'. In its interior there are three worms made of ⅛ inch copper. These are 4 inches in diameter, and are drawn out without soldering, and are joined to each other through flanges. These worms, S, S^1, and S^2, are held by three cast iron supports, s, that are seen in Fig. 9. They present a total heating surface of 215 square feet. All along the cylinder there are glazed sight-holes, a. The upper spiral of the bottom worm comes opposite the lower sight-hole, and this corresponds to the level of the sirup designed for the first concentration.

Each of the worms terminates in a valve, T, T^1, and T^2, which connects it with a steam-collecting pipe, t. At the end of this collector, a pipe, v, provided with a cock, V, leads the steam into the pipe, e, through which the sirup enters. The cock, V', on the other side of this pipe, e, serves for introducing water.

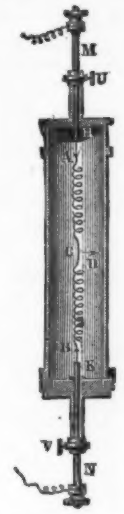
The lever, D, terminates in a handle, which projects above the floor, and is within reach of the foreman. A hand-wheel, D', permits of pressing the valve against its seat in order to secure tightness.

As in the evaporating apparatus, there are pressure-gauges, m; an air-cock, I; a grease-cock, G; a cock, P, for taking out samples; and a cock, E, for the introduction of the sirup.—*Publication Industrielle.*

ROITI'S ELECTRO-CALORIMETER.

THE current passes through a helix formed of several metals, and heats and distorts it. The distortion obtained is measured after a certain length of time, and may, within certain limits, be considered as proportional to the quantity of heat developed by the current in the circuit's unit of resistance during a unit of time. This applies likewise to any variable currents whatever, because the induction of the helix upon itself is very slight. Instead of one, I use two spirals of the Breguet type, both rolled from left to right. One of them, A C (Fig. 1), is silvered externally, so that it expands by heat, while the other, C B, which is silvered internally, contracts. Both are soldered at their extremity, C, in such a way as to form a single helix, A B, which, on being stretched out vertically and fixed at its two ends, revolves, in one direction or the other, according as it is heated or cooled, an index, C D, carried by the soldering in the center. In order to observe very slight deflections, I have usually had recourse to a small mirror, which permits of the reading being done with a spy-glass, upon a scale placed at a distance.

Two small copper rods, M H and K N, provided with terminals, serve to guide the current into the helix; but in order to better localize the heat, I have interposed two small German silver wires, H A and K B, between the helix and rods. These wires move with slight friction in two sheaths fixed in the center of two ebonite desks. Once regulated, they are fixed by means of screws, U and V. The two ebonite disks are screwed to the ends of a brass tube (Fig. 2), which is provided at the side with several apertures, two of which are large, and are formed alongside of the mirror. The object of this perforated tube is to keep the two ends of the helix united, and to permit the mirror to be placed in any position without forcing the Breguet spirals. To this end it is accurately adjusted in an aperture in the cover and bottom of the calorimetric jacket, which is double, and is capable of holding a sufficient quantity of water to protect the internal chamber and the two spirals from sudden variations in temperature. Water might also be made to circulate by means of two cocks, C C'; but of this no need has ever been felt. The slow adjustment of the tube and mirror is effected, as usual, with an endless screw, Z, and a wheel with helicoidal teeth. The manner of operating is of the simplest character; it suffices to close the calorimeter upon itself by means of a key, in order that the current be always excluded from it, except during the time that the key is kept open. Nothing is easier than to render the opening automatic, in such a way as to have for each series of observations a perfectly constant duration. Up to the present the operation has been done by hand, in counting the number of oscillations of a metronome or pendulum. This observation was made by a special observer. The person who stood at the telescope made it his business merely to read upon the scale the initial position and the maximum deflection obtained.



In order to give some idea of the sensitiveness of this first model of the electro-calorimeter, I may remark that a current of two-hundredths of an ampere produces in fourteen seconds an increase of one millimeter in the deflection when the scale is 160 centimeters from the small mirror.

From the few experiments that I have made with this instrument, I am convinced that it is well adapted for a study of the heat developed in a circuit by the discharges of condensers, such as that produced by a Ruhmkorff coil, etc. It is well to observe that in these cases of high tensions it will be necessary to cut the ebonite disks and make flat spirals of them, so as to render the insulation better. When it concerns very strong currents, I have found it advantageous, rather than to pass them into the calorimeter for a very short time (which would give the mirror a too abrupt shock),

FIGS. 1 AND 2.—ROITI'S ELECTRO-CALORIMETER.

to place the apparatus in a derived circuit, as if it were a question of a galvanometer. In this way, by graduating the resistance of the derivation, we can vary the sensitiveness at will.—*A. Roiti, in La Lumiere Electrique.*

SOME THOUGHTS ABOUT THE TELEPHONE.

THE discovery of the microphone by Prof. Hughes, and the construction of metal microphones capable of transmitting speech, have altered the aspect of the question affecting the originality of the ordinary telephonic transmitters in use. It is now seen that the crude transmitting apparatus of Reis, however imperfect in a practical sense for the purpose of speaking to a distance, does of necessity contain the practical principle of the microphone, although Reis himself may not have been entirely aware of it. He did not discover the microphone pure and simple, operating without a tympan, and as a general property of loose contacts between conductors traversed by an electric current; but he hit upon a form of microphone combined with a tympan, which acted as a current regulator, and was capable of transmitting spoken words or parts of words. The discovery of the true microphone remains with Prof. Hughes, in spite of what both Reis and Edison did, because he elucidated the whole subject, and the conditions of microphonic action, besides inventing apparatus which operated in a different manner, *i. e.*, without the use of a tympan and under the direct action of the air, or through molecular vibration of a body as distinct from tympanic pressure. He also showed how, by his delicate microphonic contacts, these vibrations could be rendered audible, and sounds, as it were, magnified. But the discovery of even an imperfect microphone in combination with a tympan by Reis, and designed for the purpose of transmitting sounds and speech, has an important bearing on the claims of Edison for originality in the "carbon transmitter," which is virtually a microphone in combination with a tympan. If the practical principle was contained in the apparatus of Reis, it follows that Edison is not the first and true inventor of a microphonic transmitter combined with a tympan, and that his original invention is limited to details of construction, the use of plumbago, etc. It also follows that other inventors are free to use the principle in question, with modifications of detail introduced by them, provided such details are not those invented and protected by Edison.

If the practical principle of an invention is public property, it stands to reason that it is only in the method of carrying it out that any subsequent improvement can be claimed as a new invention.

Let us consider this point at greater length. The Edison patent, which holds the ground against so many microphonic transmitters, claims "the combination of a diaphragm or tympan with *a tension regulator*, substantially as described." In some recent forms of transmitter there is no tympan in the ordinary sense; but the point may be disputed in a court of law. It therefore appears that if the Edison patent be held to include all kinds of tension regulators, whether of carbon or metal, in combination with a diaphragm, it must also include the platinum transmitter of Reis, which can be regarded as a platinum microphone combined with a tympan. It is true that the combination claimed by Edison is specified to be "in a closed circuit," and it is usually believed that Reis' instrument interrupted the circuit. But this is only true in part. One of Reis' instruments (date 1860-61), as a look at it will show, had a spring pressing on the contact as if to keep it close, and it could also be worked without breaking the circuit, as, perhaps, it did. The fact that Reis obtained words through it shows that it acted sometimes as a microphone, or true tension regulator, in the Edisonian sense. It matters not that Reis himself did not fully understand its working, and spoke of interruptions. The instrument was there, and we can now understand better than he how it works. I have heard words transmitted by the platinum contacts of a transmitter which was simply a copy of Reis' instrument. It follows that Reis' transmitter, being a microphone, when the sounds were not too strong to interrupt its circuit, antedates the Edison patent, and invalidates its claim. This is a view of the case which might legitimately be advanced on fair grounds, and which on due consideration must recommend itself to an electrical expert, whatever he may think of it at first.

One can admit that Reis did not *publish* the microphonic principle as Prof. Hughes did, and that he probably did not realize its existence, although it must to a certain extent have operated in his instrument, judging by his results, and the actual microphonic construction of the apparatus. But Edison himself does not appear to have realized or published the microphonic action at work in his original carbon transmitter. On the contrary, he seems to have regarded its operation as due to an inherent property that plumbago possessed of varying its resistance under pressure. It was Hughes who discovered the peculiar microphonic principle of a loose or imperfect contact, and this fact ought never to be forgotten. It was only after Hughes' discovery (which applied to metals as well as carbon, conductors as well as semi-conductors) that Edison's instrument was seen and shown to work on the microphonic principle; and the Blake instrument, if not also the carbon button instrument, were fashioned by the light of Hughes' discovery.

It follows that if we allow Edison's instrument to be a form of microphone, we must also allow Reis' 1860-61 instrument to be another form of microphone. Both of them consist of tympans in combination with tension regulators. The use of carbon in one, and metal in the other, has nothing to do with the question, for since Prof. Hughes' discovery, and the construction of actual speaking instruments with metal instead of carbon contacts, it is known that metals also make tension regulators. The weakest point in the argument is that Reis' instrument did not always work in a closed circuit; but this is a question of degree rather than of kind. With louder sounds the circuit would be interrupted, with feebler sounds it would remain "closed" in the sense that the current would not be quite broken, though "regulated" in strength. The circuit of a "Blake" transmitter could also be broken if one spoke loud enough. Every microphonic arrangement is liable to interruptions of the circuit by loud sounds; and the spring in the Blake instrument which presses the contact surfaces together has its exact counterpart in the spring which Reis employed to press his platinum surfaces in contact. In fact, the Reis 1860-61 transmitter is essentially a microphone like the Blake. It has all the elements of the Blake instrument—tympan, contact points, and spring adjustment. Substitute hard carbon for one of the contacts in the Reis instrument, and you have substantially a Blake transmitter.

The reason why the Reis contacts are so apt to open the circuit, as compared with the contacts of the Blake, is that they are both of platinum. Had one been of carbon this difficulty would have disappeared, and M. Reis would have thoroughly succeeded in producing a practical telephone. He would, in fact, have completely anticipated both Edison and Bell. As it was, he failed from the materials he used, rather than in principle. I have found from experiment that metal contacts, and especially platinum ones, are very apt to open the circuit under the vibrations of the voice, and the reason probably is that the "arc" or air discharge which connects them when they are vibrated is very short; shorter than in the case of carbon, if not some other metals. Hence, in order to preserve the continuity of the circuit, the vibrations of the voice must be much feebler than in the case of carbon. This was the chief difficulty in the way of Reis—a difficulty of

detail, not of principle. We have metal contacts now which overcome it, without having to resort to carbon at all.

The chief points of the argument, then, as set forth above, are as follows:

1. In 1860-61 Philipp Reis constructed a telephonic transmitter with platinum contacts, and a receiver consisting of an electro-magnet with a thin iron armature in front of its poles, and vibrated by the current. (See Silvanus Thompson's work entitled, "Philipp Reis, Inventor of the Telephone," for a full description of the apparatus).

2. The Reis receiver is essentially a Bell receiver, the difference between them being one of detail.

3. The Reis transmitter is essentially a metal microphone; of an imperfect construction, it is true, but still a microphone. The metal used was platinum.

4. Edison's transmitter is essentially a carbon microphone. Blake's transmitter, which is a form of Edison's, is a carbon and platinum microphone.

5. Reis' microphone was combined with a tympan; so is Edison's and Blake's.

6. Being a microphone, Reis' transmitter is a "tension regulator" of essentially the same nature as Edison's and Blake's; the difference consisting mainly in the materials used, and being one of degree rather than of kind. Both can operate "in a closed circuit," provided the loudness of the voice is graduated to suit each instrument.

7. Therefore Edison's claim for *the combination of a tympan with a tension regulator in a closed circuit* is anticipated by the Reis transmitter (and cannot be sustained).

The claim of Edison is, in fact, too comprehensive—fatally so. Had he confined his claim to the use of lamp-black, plumbago, or even semi-conducting materials (as he did originally in his English patent before it was amended to make it more sweeping), for his "tension regulator," it might have been more secure; because we do not know that Reis used such materials. But, in extending it, he has brought his claim into antagonism with the earlier work of Reis.

There is no need to dwell upon the work of Prof. Hughes, because it is his discovery which has thrown light upon the whole subject. Moreover, it was apparently Prof. Hughes who showed Edison himself, and likewise Blake, that hard carbon contacts were preferable to lamp-black and plumbago. It is only since the Hughes microphone was brought out that hard carbon has been used in transmitters with such success. Prof. Hughes has also enabled us to see that Reis' instrument was in reality a metal microphone, and led the way to the production of metal microphones which act as transmitters. These instruments might be regarded as improved forms of the Reis microphone. So may Edison's, since they are all "tension regulators" in a closed circuit. Moreover, they have this advantage, that they have no tympan like the Reis instrument, and are in this respect more distinct from it than Edison's instrument.

The disuse of a "tympan" also comes from Prof. Hughes' discovery, since he found that a tympan was unnecessary.

The question as to what constitutes a "tympan" has been much debated in this country, and some eminent authorities have held that anything constitutes a "tympan." Some are believed to have said that the earth itself constitutes a "tympan." For example, if you lay a microphone on the ground, the latter becomes a tympan. Did Edison, then, intend to patent the earth? Surely not. But even if he did, he could not. The supposition is absurd, but it serves to show the fallacy of the view. What these authorities meant was that the earth would act as a physical vibrator. But here we discern how the fallacy arose, for a vibrator in the physical sense is not necessarily a "tympan" in the technical sense, any more than a block of wood is a table or a bundle of straw is a folding bedstead. By a "tympan or diaphragm," Edison meant a tympan or diaphragm in the usual sense, and nothing else. Had Professor Hughes not shown that these well known devices were not necessary to the working of the microphone, we should never have heard that a tympan was anything else but what it is generally understood to be; and it would not have been necessary to strain the meaning of the word so as to make it include such diverse objects as a block of wood, a quantity of water, or of any vibratory body.

Indeed, if any vibratory body is to be considered as a tympan, we cannot exclude the material parts of the microphone. Hence the Edison claim may be interpreted as the combination of a tension regulator with itself—a conclusion which is absurd.—*J. Munro*, in *La Lumiere Electrique*.

A NEW ARC LAMP FOR PROJECTIONS.

IN the *Elektrotechnische Zeitschrift* for July we find a description of a new arc lamp devised by Mr. R. Ruhmann, and designed for projecting purposes. The essential condition that such a lamp should satisfy is that the luminous center be stable with respect to the body of the lamp, or, in other words, that the luminous center be invariable in space. An endeavor ought evidently to be made also to have a steady light. This, however, is a condition that is necessary in every kind of a lamp. Moreover, the lamp should be capable of operating in any position, that is to say, the mechanism should be based upon the action of gravity.

Mr. Ruhlmann's lamp, which is shown in section in Fig. 1, seems to satisfy these conditions pretty well. It is based upon the well-known principle of the sun lamp. The two carbons, R and R', under the action of two weak springs, F and F', bear against the sides of a block, B, which is formed of a refractory substance, and contains in its center a channel, *a* (Figs. 1, 3, and 4), that gives passage to the voltaic arc. At the back of the block, B, there is a funnel shaped opening, through which the luminous rays escape.

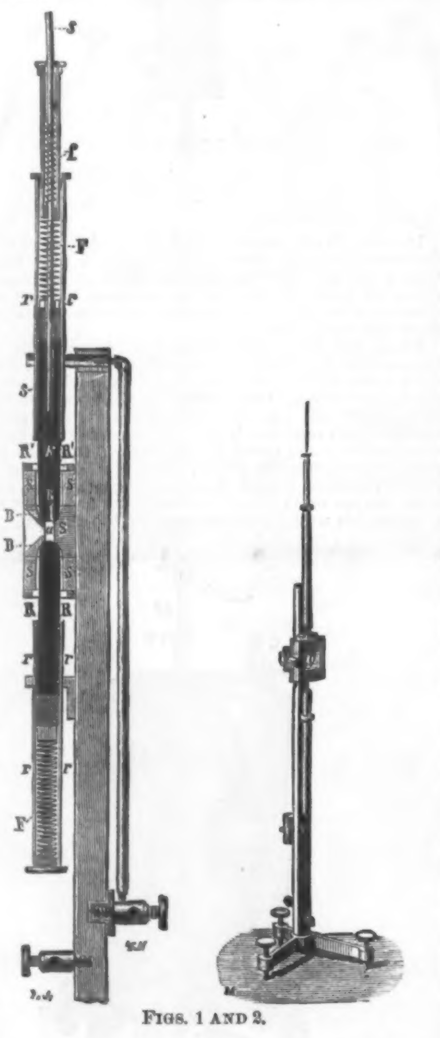
The carbon crayons are fixed to copper rods, and are guided in tubes, *r r*, of the same metal. The lower carbon is connected, through metal, with the body of the apparatus, and from thence with the positive pole of the source of electricity. The upper carbon is insulated from the apparatus, and communicates with a terminal which is connected with the negative pole of the source.

For lighting, the upper rod, *s*, is depressed, and with it the carbon crayon, *k*, which slides in an aperture in the carbon, R', until it comes into contact with the carbon, R. At this moment the current passes, and the carbon, *k*, is left to the action of the spiral spring, *f*, which causes it to slowly rise. The channel, *a*, is wide enough to allow *k* to pass, and narrow enough to prevent the two electrodes, R and R', from coming together. When the lamp is lighted, it is well to draw the carbon, *k*, back slowly, in order to allow the arc, in measure as it elongates, to have time to heat the neighboring sides of the block, B. When such precaution is neglected, the lamp goes out easily in the beginning.

The block, B, whose different points are raised to more or less high temperatures, soon becomes fissured. So, in order to prevent it from becoming detached, it is held in an envelope of calcined koreite inclosed in a cast iron box.

What, according to the inventor, differentiates his lamp from the sun apparatus is the use of a material rich in carbonate of magnesia for the manufacture of the blocks.

As a consequence of the great rise in the temperature, a dissociation occurs, carbonic acid separating, and a part of the remaining magnesium oxide being volatilized. These blocks keep very well, but it is difficult to shape them, on account of the nature of the minerals employed. The inventor likewise recommends the use of dolomite, which is more easily worked, and which, as regards duration, gives good results. For a from 8 to 10 millimeter space between the carbons the lamp requires a difference of potential of 45 or 47 volts at the terminals.



FIGS. 1 AND 2.

Fig. 2 gives a general view of the lamp. The mounting is such that the lamp may without modification be applied to the principal projecting apparatus found in the market, such as that of Talbot, Fritz, Liesegang and Stochrer, and others.

When blocks with crateriform aperatures (Fig. 3) are used, the luminous intensity is, for the same expenditure of electric energy, less than in a Siemens lamp whose positive carbon has been pulled back a little in order to throw the light forward. This is due to the fact that the points of the electrodes are shielded by the sides of the block, B.

The luminous intensity is sensibly increased by splitting the block lengthwise, and giving it the form shown in Fig. 4. In this case the luminous intensity is, all things else being equal, greater than that yielded by ordinary lamps, although the blocks wear away a little more quickly.—*La Lumiere Electrique.*

ELECTRIC LIGHTING ON SHIPBOARD.

A PAPER recently presented to the British Institution of Civil Engineers by Mr. Andrew Jamieson gave rise to an exceedingly interesting and instructive discussion. The author of the paper considered the advantages of the electric light on board ship to be summed up in the following points: Its healthfulness; freedom from heat, odor, or gaseous products; its general agreeableness; its freedom from danger of setting fire to combustible material; removal of the danger of storage of inflammable illuminants; avoidance of the nuisance of cleaning and refilling lamps; reduction of space occupied by total plant; and a fair competition in cost of illumination.

The dynamo should be placed with its axis in the fore and aft line, in order to reduce the gyrostatic effect caused by rolling, and thus to lessen the heating of its bearings. It should be capable of developing the required electromotive force at its regular speed; should be self-regulating; should not "spark"; should not heat the conductors when running light; should contain, either in its own coils or in the conducting system, not less than ninety-six per cent. pure copper; and the system should have an insulation resistance of not less than ten thousand ohms per volt, generated at the regular speed of working. The speed is generally preferred to be under six hundred or six hundred and fifty revolutions per minute. Higher speeds demand more careful supervision, give rise to danger of heated bearings and sometimes of bursting the armature, cause objectionable gyrostatic action in uneasy ships, and make it difficult to drive by direct connection.

The engine should be capable of driving continuously and indefinitely as to time, without danger of heating or break-down. Its governor should control the speed within five per cent.,* with variation of steam-pressure of ten pounds or more per square inch, and a variation of load of ninety per cent., *i. e.*, with full load, or with nothing on but the dynamo. A tachometer, or continuous speed-indicator, is a valuable adjunct to the engine as exhibiting all variations of speed. An electrical governor acting upon the throttle-valve is thought to be a desirable instrument.

When not driven directly, the dynamo is, as a rule, connected to its engine by cotton rope, the steel-wire coiled belting coming into use in the United States not apparently having been introduced into Great Britain. The Westinghouse engine is reported to be doing excellent work. Brotherhood's "three-cylinder engines" and the Tower "spherical engine" are also working satisfactorily. Friction pulleys have been used, in some cases, instead of belting, for indirect connection.

The system of distribution is usually one of two principal kinds: in the one method, a set of return wires is used; in the other, the hull of the ship takes the return currents. The latter system is the less costly and more easily fitted, and gives rise to less resistance: but it has the disadvantages that a fault in the leading wire has more effect than in the other, a contact with the hull short-circuiting the current; it is more likely to be injured by leakage of salt water upon the conductor, in which event corrosion goes on with serious rapidity; but care in protecting the wires, and in placing them, reduces the danger from these causes to a very small quantity.

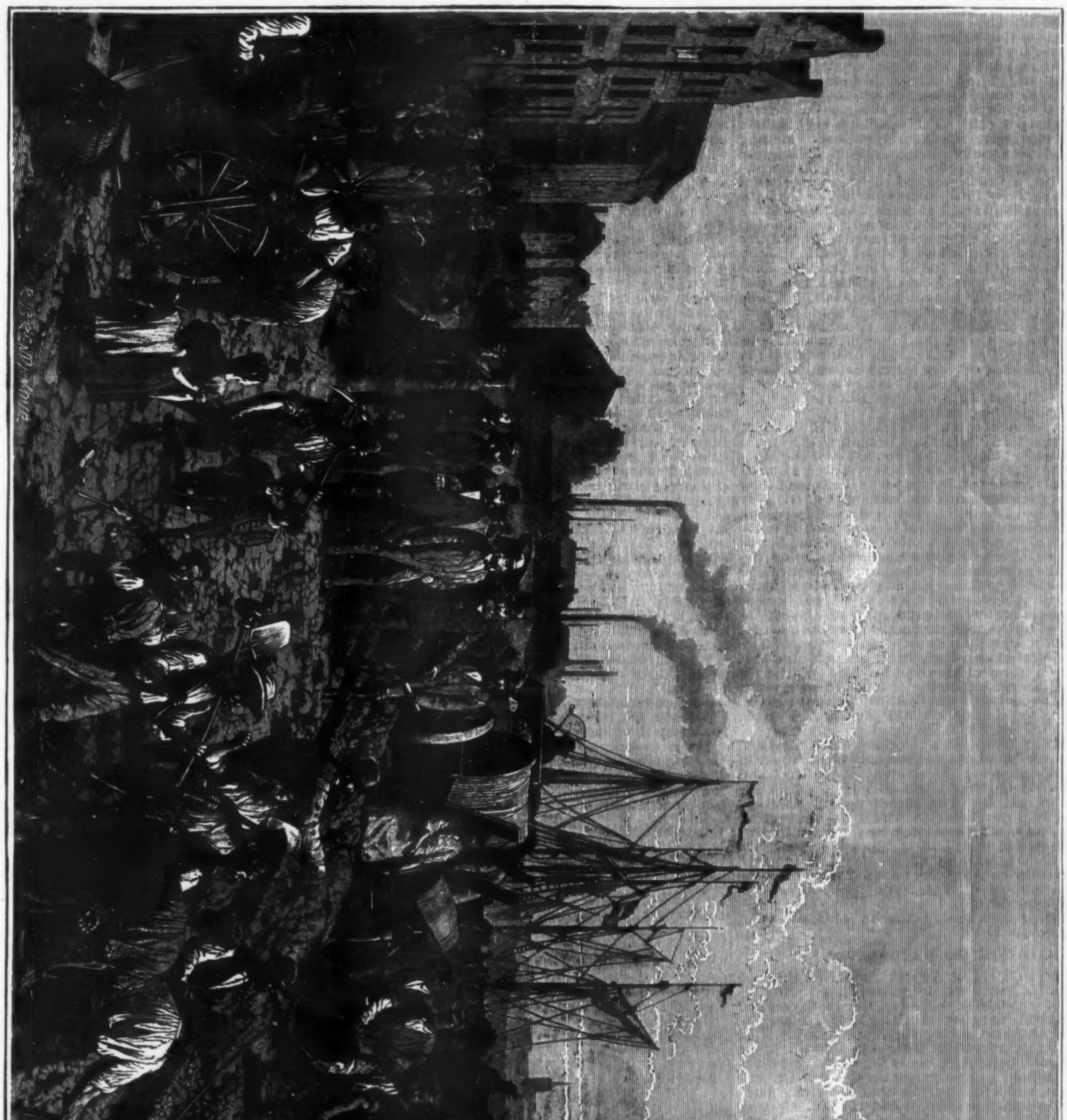
It is of great importance that the junctions of wires should be very carefully and thoroughly soldered; and the size of wire should be such that it should give at least a square centimeter area per fifty amperes, according to the rule of Sir William Thomson. But the author of the paper would adopt the rule: Make the conductivity of the wire not less than ninety-five per cent. that of pure copper, and give it a cross section of a square millimeter for an ampere and a half of current, or about a square inch to a thousand amperes; the insulation resistance of the whole circuit, including switches, etc., to be not less than a thousand ohms per volt of electromotive force of the dynamo. Failures are usually due to neglect of the precaution of testing the insulation when the plant is put in place. Safety-wires, to prevent the overheating of any part in case of wires crossing should always be introduced.

The size of lamp should be ten-candle power for staterooms or "cabins," twenty-candle power for the saloons and larger rooms, and fifty to a hundred candle power for above-deck illumination. Arc-lamps of ten thousand to twenty thousand candle power are used on men-of-war for illuminating the surroundings of the ship, and for protection against the unobserved approach of torpedoes.

UNDERGROUND CABLES IN GERMANY.

THE question of underground wires, which is now being agitated in American cities, has so far been answered abroad, in the affirmative, that in several countries, and notably in Germany, the underground system has even been adopted for communication between distant cities. It was in 1875 that Dr. Stephan, the Director-General of German Posts and Telegraphs, conceived the idea of that great underground network of telegraphic cables which now connects the principal cities of the empire. The favorable results which had been obtained from the cables of galvanized iron wire, insulated with gutta-percha, which were manufactured by the well-known engineering firm of Felten and Guillaume, of Cologne, induced the Government to experiment with this cable, and finally, in the following year, to adopt it in the construction of the underground line between Berlin and Halle. This was recognized as simply experimental. The distance between the two cities is 120 miles, though the connecting cable had a length of 175 miles. There were seven conductors in this cable, and consequently a total mileage of 1,225 miles. The work of construction began in March, and was completed during the following July. This line was eminently successful, and demonstrated to the satisfaction of the administration that the rapidity of transmission was adequate, and that the inductive action of the parallel currents would cause no embarrassment. In consequence, the system was extended over the entire empire, and as finished in 1880 had a total length of cable of 4,000 miles, and of conductors of not less than 28,000 miles. A portion of this network was constructed of cables composed of seven copper wires, 0·6 of a millimeter in diameter, and insulated with gutta-percha and Chatterton compound. The size and number of the conductors varied in the different cables, but were usually greater in those of later construction. The joints in the cables occurred, as a rule, once in every kilometer, and were protected by means of cast iron boxes. After the laying of each section, electrical tests were made upon the whole of the cable in place, in order to prove the joints. Ditches to receive the cable were made about one meter deep, except in those places where masonry or rock interfered, and then a depth of three-quarters of a meter was deemed sufficient. In transporting the cables, they were wound on large wooden bobbins, and were protected by a covering of straw and sheet iron. The work of laying a cable is shown in our illustration, for which we are indebted to the *Journal Universel d'Electricité*. Since the establishment of the system, electrical tests have been made once every month, and show that in some cases the insulation has

* In the United States, a variation of two per cent. is considered too great.



MODE OF LAYING UNDERGROUND TELEGRAPH CABLES IN GERMANY.

improved, while the oldest cable, laid about nine years ago, is as good to-day as when first laid. The cables of the entire system have been manufactured by the same firm, and have cost, in position, about $7,800,000. The example of Germany has since been followed by France, where underground cables are largely in use. They give, as a rule, the same rapidity of transmission as the aerial lines, and, from their protection from the atmosphere, are much more durable. Since the introduction of the telephone and electric light, Messrs. Felten and Guillaume have made enormous quantities of cables for these purposes. Those surrounded with lead, and insulated with impregnated hemp, are well known in the electrical world. The wire cables used on the San Francisco cable roads are also of their manufacture, and show that this well-known firm have been able to attain excellence in several directions.

In some tests made with small squares of various woods buried 1 inch in the ground the following results were noted: birch and aspen decayed in three years; willow and horse chestnut in four years; maple and red beech in five years; elm, ash, hornbeam, and lombardy poplar in seven years; oak, Scotch fir, Weymouth pine, and silver fir decayed to a depth of half an inch in seven years; larch, juniper, and arbor vitæ were uninjured at the expiration of the seven years.

CERTAIN INTERESTING CRYSTALLINE ALLOYS.*

In the treatment of auriferous copper containing bismuth, I have recently observed a small quantity of a grayish white alloy, which on examination proved to be Bi, containing in solution, as it were, a crystalline alloy of Bi and Au. This compound makes its appearance on the surface of the auriferous Cu in small globules as the latter cools. These globules are rapidly attacked by nitric acid, and fine needle-shaped crystals of Bi and Au separate out. They are insoluble even in strong nitric acid. On examination, the crystals were found to contain: Gold, 69·94 per cent.; silver, 0·63 per cent.; bismuth, 29·43 per cent. The residue is very fusible, and at a temperature considerably below its melting point it oxidizes rapidly, changing from its original gray color to a greenish yellow. On melting in a crucible under flux, a bronze-colored alloy is formed that has a specific gravity 15·47—somewhat higher than the calculated specific gravity of a simple mixture of the two metals in the proportions named. In following out my investigations by repeated examinations of this alloy formed at different times, I found that in dissolving a miscellaneous lot of the alloy in nitric acid, some gold-yellow crystals were formed, which I succeeded in separating from the BiAu alloy by washing. These yellow crystals, under the microscope, showed distinct, regular, octahedral faces, and on examination they were found to be a crystalline alloy of Au and Ag in the proportion of 69 Au, 21 Ag. The quantity was too small to admit of any very correct determination of these crystals; but the peculiar feature was remarked that they contained Ag, while the BiAu crystals did not in any appreciable quantity.

My next experiment was to remelt some of the original Bi compound with Ag, so arranging that the Ag should exist in the melted alloy in the proportion of one atom of Au to one of Ag. The alloy was prepared by melting in a small crucible under a layer of borax, and then allowing the crucible, with its contents, to cool very slowly. This was done by placing the small crucible inside a larger crucible that had been previously made red hot, and allowing the whole thing to stand until cold. The small crucible was then broken, and the button of alloy detached. This alloy was found to be very brittle and crystalline. It was broken into lumps and treated in a flask with dilute nitric acid—one of acid to three of water. I found, after all the Bi had been attacked by the acid, that nothing was left behind but a beautiful crystalline alloy of Au and Ag. There was an entire absence of any BiAu compound, which was found in former experiments. The solution of nitrate of Bi showed no trace of Ag. These crystals were found to contain: Gold, 62·164 per cent.; silver, 35·486 per cent.; Cu and Bi, 2·35 per cent. Further boiling of the crystals with strong nitric acid gave (No. 5): gold, 65·21; silver, 33·19; copper, 1·60. Alloys of gold and silver in all proportions may be obtained in this way, depending on the amount of Ag used and also on the strength of nitric acid employed in the separation of the Bi. The largest and best formed crystals are, however, those in which the Au and Ag exist in the ratio of their atomic weights. Repeated boiling with strong nitric acid will, however, remove a portion of the Ag, without in any way damaging the crystals or effecting any very marked change in the color. In a number of experiments that I have made with the alloys of Au and Ag, the lowest percentage of Au resulting from treatment with HNO_3 was 58·51, and the highest 94·15.

ALLOYS OF GOLD AND COPPER.

Crystals of an alloy of Au and Cu may be obtained precisely in the same way by substituting Cu for Ag. The form of crystals is the same, that of the regular octahedron, but they are much smaller. A crop of crystals was obtained having the composition 61·52 Au and 38·48 Cu. On treating these crystals with strong nitric acid, and boiling for some time until there was no further action, a large percentage of the Cu was dissolved out, and a product was obtained a little darker in color, containing 93·49 Au and 6·51 Cu. Crystals were also obtained containing all three metals in the proportion: Gold, 60·16; silver, 21·2; copper, 18·63. These experiments indicate that Au will not combine with Bi if Ag or Cu is present in sufficient quantity. The crystals of Au and Bi are in fine needle-shaped forms, the system of crystallization not determined, but possibly rhombohedral (the crystalline form of Bi). Au, Ag, and Cu crystallize out together from a solution of these metals in Bi; the mother liquor, if I may use the expression, containing no Ag or Cu unless these metals are present in excess of what is required to form alloys that will resist the action of dilute nitric acid. The following experiment was made with the view of determining the solvent action of Bi, melted at a low temperature, on the crystals of alloy of Au and Ag formed by the process that I have described. An alloy was made by melting Au and Ag in about their atomic proportions with Bi, and allowing to cool slowly. The alloy was then heated in a small iron ladle until it became liquid, care being taken not to increase the temperature much above the melting point. The liquid portion was then poured off, and the residue of crystals drained until a pasty mass was obtained. The temperature was then slightly increased, and a further quantity of molten Bi poured off. The percentage of each product was as follows: 56 per cent. of the total weight was poured off at the first melting at a low temperature; 19 per cent. after a slightly increased temperature; the rest, 25 per cent. (the pasty mass), retreated with dilute nitric acid, gave a crop of good crystals, which were found to contain: Gold, 59·06; silver, 37·21; Cu and Bi (by diff.), 3·73. Treated with strong nitric acid, their composition became: Gold, 68·53; silver, 27·54; copper, 3·93. I found in this experiment that the pasty residue in the ladle contained only about 62 per cent. of the total gold, the remainder being carried off by the liquated Bi. The ratios of the gold and silver in these three products were as follows:

(Approximately.)

First liquation....	Au 74·16	Ag 25·84	Au_3Ag_2
Second liquation..	Au 65·35	Ag 34·65	AuAg
Pasty residue.....	Au 71·33	Ag 28·67	Au_4Ag_3

In all these alloys of Au, Ag, and Cu, the only crystalline form observed was that of the regular octahedron without any modifications.*

ALLOYS OF BISMUTH AND PLATINUM.

Experiments were made to see how far it was possible to prepare in a similar way crystalline alloys of platinum and bismuth. Pt and Bi were melted together and allowed to cool slowly in the usual way. The brittle alloy was treated first with dilute nitric acid and then with strong acid. A black crystalline powder was obtained, which, under the microscope, showed some few crystals, form not determined. A second experiment was made with the addition of Cu to a similar mixture as before. A highly crystalline jet-black residue was obtained, which, on examination, proved to be binoxide of platinum. Crystalline alloys are obtained in the same way as with Au; but these compounds, unlike those containing Au, are decomposed by nitric acid; the metals Bi and Cu that entered into the composition of the alloy being entirely replaced by oxygen, and this without destroying the structure of the crystal. The black crystals became red hot in a current of hydrogen, water being condensed on the sides of the tube, a grayish-white powder of Pt being left behind. A loss of weight was sustained in this experiment equal to 13·75 per cent., which is very near the amount of oxygen required by the formula PtO_2. On heating in a tube, it gives off O, a grayish-white powder of Pt remaining. The black crystals can be ground easily in a mortar without showing the slightest evidence of metallic particles. Alcohol is readily oxidized by this compound. On heating the crystals, a trace of reddish-brown gas is given off, probably due to a small quantity of occluded nitric oxide. If it were possible to attack the Bi by some acid that is not oxidizing, we should unquestionably obtain crystals of the alloy of Pt and Bi, or Pt and Cu, or perhaps Pt, Bi, and Cu; but on using nitric acid as the solvent, we have to be content with pseudomorphs of PtO_2 after the alloy. In order to avoid the use of nitric acid, an experiment was made by substituting Zn for Bi, in the hope that crystals would be formed that could be separated by dissolving out the Zn with H_2SO_4. A black powder was obtained in this way, showing, however, no evidence of crystallization. On treating the black powder with nitric acid, Cu was dissolved to the extent of 20 per cent., and a grayish-black residue was obtained, which, when dried, possessed highly oxidizing properties. It instantly ignited a drop of alcohol, and exploded a mixture of hydrogen and air. What the exact nature of this substance is I have not determined; but it differs materially from the crystalline black substance prepared from the Bi alloy. From the loss sustained on ignition (less than one-half required for PtO_2), it would appear to be finely divided platinum intimately mixed with PtO_2. Its oxidizing properties are, however, far more energetic than were shown by the previous compound.

These experiments that I have drawn attention to may be regarded as being of a preliminary character. They offer, however, a field for further investigation that would in all probability lead to some interesting facts connected with the composition of alloys.

* Paper read before the American Institute of Mining Engineers by Mr. Richard Pearce, Denver, Col.

* The Bi used for most of these alloys was somewhat impure, containing notably a little copper.

BUTTER AND FATS.†

By Dr. Thomas Taylor, Microscopist, U. S. Department of Agriculture.

"Since 1876, when my first paper was published on Butter and Fats, in the *New York Microscopical Quarterly Journal*, I have devoted a good deal of time to the investigation of this subject, principally with the view of finding a method by which I could, by the aid of the microscope, detect butter from butter substitutes. As a result of many experiments, I find that a person experienced in the use of the microscope may distinguish the fats of various animals and of vegetables by following the methods herein described.

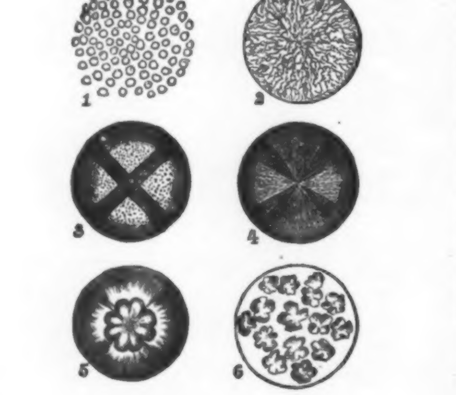


Fig. 1.—Represents crystals of boiled butter as seen by a pocket lens.

Fig. 2.—A single crystal of butter, highly magnified, viewed by transmitted light only.

Fig. 3.—A crystal of butter viewed by polarized light only. It exhibits the cross of St. Andrew.

Fig. 4.—A crystal of butter as seen under polarized light and selenite plate. In this case beautiful colors are displayed, while the cross is but faintly seen.

Fig. 5.—Represents what seems to be a budding butter crystal. See description.

Fig. 6.—Represents the rosette crystals of butter.

Fig. 7.—The crystalline form of lard.

Fig. 8.—The crystalline form of beef.

"The experimenter should first procure a specimen of common lard. This is composed mostly of crystalline starry forms which represent the solid fat of the lard. Real lard is composed of these and the oil common to lard. In very hot weather, when the thermometer is up in the nineties, the crystals dissolve in the oil, and perfect crystals cannot then be obtained unless cooled slowly to about 70° Fahr.

"Place a drop of sweet oil on a glass slide 3 × 1 inches, with the point of a needle. Place a small portion of the lard in the oil, and mix them together. Place a microscopic glass disk over the lard and oil mixture and press gently. If held up to the light, white granules will be seen if the temperature is not over 80° Fahr.; these are fatty crystals. Under a low power of the microscopes it will be observed that these crystals have stellar forms with dark centers, and spines radiating from them. See Fig. 7.

"To procure normal crystals of beef kidney fat, render a piece of this fat in an iron pan, without water. Strain, and add sufficient sweet oil to bring the fat to the consistency of butter. Cool slowly for a period of from twelve to twenty-four hours. Mount in oil as directed in the case of lard. The crystals in this case present quite a different appearance from those seen in lard. See Fig. 8. View them by polarized light, with and without selenite plate. The beef crystals, to be seen to advantage, require a power of at least 500 diameters, being very small, although they appear very interesting objects with a power as low as 80.

"When it is desired to examine the crystals of butter, boil about an ounce of pure, newly made butter in a test tube or iron spoon for a period of several seconds; allow it to cool as directed in the case of beef and lard; place a few grains of it on a slip of glass; pour over it a few drops of alcohol (or better, with alcohol nine parts, carbolic acid one part); separate the crystals with a pin, and view them with a pocket lens; they will appear like the eggs of insects, Fig. 1. Place a second portion of the same butter on a glass slide 3 × 1 inches; combine it with a drop of sweet oil by means of a pin, reducing the butter to granules; cover with a thick disk of glass, and view first with plain transmitted light, when crystals like Fig. 2 will be seen. Second, by polarized light. In this case place the polarizer low down and turn this prism round until its face angle crosses the face angle of the analyzing prism above. Under these conditions a dark ground is produced, and the butter crystals, which are globular in form, are seen in bold relief. The butter globular crystals will now exhibit a well defined black cross representing that known as St. Andrew's. See Fig. 3. Fig. 4 represents a crystal of butter showing divisions produced in prismatic colors when the selenite plate is used with polarized light. If old butter or a poor oily butter is used in this experiment, the secondary crystals of butter are generally shown. These crystals are of rosette form, much smaller than that of the globular, and exhibit no cross. See Fig. 6.

"The globular crystals of butter, when kept for a month or more, seem to bud like a vegetable spore, and frequently every round crystal will show projecting from each a smaller crystal. See Fig. 5. The globular forms generally vary from fifteen ten-thousandths of an inch to the one-hundredth of an inch in diameter. These forms are never seen in pure beef or lard fats. Care should be observed not to press the crystals flat, especially the globular crystals, as the cross is not seen when severely pressed.

"Butter crystals vary slightly from each other in size and in some other slight particulars, such as color. A butter received from Tennessee, made from milk of Holstein and native breed, shows on its crystals indentations, a condition represented in no other butter yet observed. The butter crystals seen in the butter made at Mr. Frank Ward's dairy, from milk of Alderney cows, of Washington, also differ in some particulars from all others examined, being darker in color, spines longer, and of larger size. Specimens intended for permanent use should be mounted with a varnish ring, to prevent the cover from pressing on the crystals, and to prevent the movement of the cover used to protect them."

Dr. Taylor has examined quite a number of other fats, vegetable and animal, and finds, thus far, that animals and vegetables of distinctly different genera, and even species, yield fats which give typical fatty crystals characteristic of the animals and plants which yield them, and he is confident that his new discoveries will prove highly useful to microscopists and chemists when investigating adulterated substances used as food or in medicinal preparations. Many scientific men have urged him to continue his investigations, the result thus far being highly appreciated.

† Abstract of paper read by Dr. Thomas Taylor before the American Microscopical Society, August, 1885, at Cleveland, Ohio.

ON THE DETECTION OF ADULTERATIONS IN OILS.

By Oscar C. S. Carter.

The chemical examination of oils is a very important though much neglected study—important from the fact that the oils which command a high price in the market and are in general demand are frequently adulterated. The temptation to adulterate is great on account of the heavy increase in profit, and because the adulterant is often very difficult of detection. The purchaser is always at the mercy of the oil merchant, unless the oil be submitted to a chemical examination. "Our former Consul at Naples reported to the State Department that immense quantities of refined cottonseed oils are sent to Italy for the express purpose of sophisticating the native olive oil, for the reason that it can be brought to Naples and sold at less than half the cost of producing pure olive oil." The cottonseed oil mixed with pure olive oil is exported to other countries. The price of fine salad oil is from three to four dollars per gallon, while cottonseed oil is worth from seventy to ninety cents per gallon. The oils commonly used to adulterate olive oil are colza oil, sesame oil, and peanut oil. In the North of France poppy oil is used frequently because of its cheapness and neutral taste, and in Provence honey is used. In all probability glucose sirup has been tried. Linseed oil, the most important drying oil in the arts, so much used in varnishes and paints, is very often sophisticated. Even the seed from which the oil is made is mixed with other seeds. In India flaxseed is grown with mustard and rape. In Russia various proportions of hemp and linseed are sown together. Hempseed yields an oil of

an acrid odor, mild taste, and yellow color, used in Russia for burning in lamps and making paints, varnishes, and soap. The oils commonly mixed with linseed oil are niger, cottonseed, fish, rosin, and coal oils. In this country lard is adulterated with palmnut and cocoanut oil; the latter is a white fat with the peculiar smell of the kernel. It was formerly made by grinding the kernel, boiling with water, and subjecting the paste to a great pressure; a large quantity of milky juice is so obtained, which is slowly boiled, and the oil separates and is skimmed off. Twenty ordinary sized nuts yield about two quarts of oil. The strong taste of these oils is an objection, and may prevent their general use as adulterants and for the manufacture of oleomargarine. Lard oil, which is obtained from lard, is very valuable as a lubricant for machinery, and is also used for greasing wool in spinning. It is frequently adulterated with fish oils and cottonseed oils. Lard oil is worth one dollar and twenty cents per gallon, while cottonseed oil is worth about one-half as much.

The chemical analysis and detection of the adulterated oil is sometimes simple, but generally it is a difficult and trying task, especially when three or more oils have been mixed. The determination of the percentage of oil used to adulterate is out of the question, and we must often be satisfied by simply proving that there has been a mixture, without knowing the nature of it. But little work has been done on oils compared to the vast amount of research given to other subjects. Chemists have avoided the study and analysis of oils as difficult and uninteresting. We owe almost all we know to the labors of Chevreul, and later to the researches of Prof. Allen and others. When oils are examined, chemical tests are the more important, but the physical tests are also very useful. At the present time we have not a characteristic test for each oil, as we have for each metal, that will distinguish it when mixed with other oils or that will identify it when alone.

When we examine an oil supposed to be adulterated, much can be accomplished by procuring a sample of perfectly pure oil, and subjecting them both to the same tests and observing their behavior. A sample of lard oil supposed to be adulterated was received from a woolen manufacturer for examination. A specimen of perfectly pure lard oil was obtained, and they were subjected to the same tests.

According to Professor Bechi, of Florence, the following test is reliable and delicate for detecting cottonseed oil in olive oil. The reagent is a one per cent. solution of nitrate of silver in absolute alcohol. Place 5 c. c. of the suspected oil in a glass flask, add to it 25 c. c. of absolute alcohol and 5 c. c. of the test solution of nitrate of silver, made as stated above. The flask is heated in a water bath at 84° C. (direct heat must not be used). If there be any cottonseed oil present, the mixture will begin to darken, the most minute quantity serving to discolor, and the tint assumed will depend upon the amount of cottonseed oil present. The test depends upon the fact that cottonseed oil will reduce nitrate of silver, but olive oil will not. This reduction is also caused by rapeseed oil, but according to Bechi, pure olive oil will remain without discoloration under this test. While experimenting with the test, I thought it might be of service in detecting cottonseed oil in lard oil; accordingly the sample of chemically pure lard oil was treated with absolute alcohol and nitrate of silver as directed, and then heated; there was not the slightest discoloration of the pure lard oil; even on standing for two weeks it did not darken, thus proving it had no action upon the nitrate of silver. The lard oil obtained from the woolen manufacturer was then tested in the same manner; when it had been heated for a few minutes, it began to darken and finally became quite black, thus proving that the lard oil was not pure, but mixed with some other oil. I am not certain that the darkening is due to reduction; having made a series of experiments with salts of mercury, copper, and antimony and cottonseed oil to see if there would be any reduction, I obtained no satisfactory results, and no reduction was noticed.

The elaidin test is sometimes very satisfactory, especially in detecting a mixture of a drying and non-drying oil and detecting adulteration of olive oil. This test depends upon the fact that olein and oleic acid in contact with peroxide of nitrogen yield a crystalline, solid, fatty body fusible at 32° C. to which Boudet has given the name elaidin. The nitrous vapors made by the action of nitric acid on copper are passed through the oil, or it may be shaken with a fresh solution of mercurous nitrate, which has the property of retaining nitrous acid. Non-drying vegetable oils and most animal fats contain oleic acid. The following oils contain a high percentage of olein: olive, almond, rape, arachis (earthnut), castor, and the oils from lard and tallow. These oils form with nitrogen peroxide solid elaidin of a white or yellow color, which in some cases is firm and resonant. The drying oils, such as linseed, hempseed, and poppyseed oils, do not form solid elaidin with nitrous vapors, but remain liquid for more than two days and become slightly colored. The elaidin test was applied to the adulterated lard oil and to the pure lard oil by adding an equal amount of nitric acid (sp. gr. 1·40) and some copper turnings. The elaidin produced by the pure oil was more firm and coherent than that of the adulterated oil, and was of a lighter color; also the nitrous fumes rose more rapidly through the pure oil. One curious fact noticed about the adulterated lard oil was, it could not be completely saponified with caustic soda; even when the latter was added in excess, a clear layer of unsaponified oil remained after several trials. This test clearly indicated adulteration, as pure lard oil will completely saponify with caustic soda. Prof. Allen has proved that shark liver oil and African fish oil resist saponification. He tried to saponify the former oil with aqueous potash, with a solution of potash in absolute alcohol, and by heating it with solid potash, but it would not completely saponify; this he thinks is due to the fact that it contains a body allied to cholesterin, but fluid at ordinary temperatures.

Pure lard oil gives with nitric acid of sp. gr. 1·33 a yellow color, approaching orange.

The adulterated sample of lard oil with nitric acid of the same strength gave a distinct brown color on standing. That portion of the oil which resisted saponification with caustic soda was treated with nitric acid, and it soon became of a deep coffee-brown color, much darker than the above.

The determination of specific gravity is the most important of the physical tests. The viscosity of an oil is a highly important feature, but in order to be of any value in testing, much care must be observed; both oils must be brought to the same temperature, and kept so while flowing. Both the adulterated and the pure lard oil were subjected to this test; they were brought to a temperature of 80° F., and 5 c. c. of each oil were passed through a capillary tube. The pure oil required 960 seconds to pass through, while the adulterated oil required 1,080 seconds. The experiment was repeated several times with different tubes, but the ratio of the times of flowing was constant. Both oils were subjected to a temperature of 32° F. When the pure oil was frozen, it was more coherent and firm and much lighter in color; the adulterated sample was quite yellow. When the adulterated oil slowly became liquid, a layer of yellow oil formed first, which was quite different in appearance from the other portion, and was evidently the adulterant.

While we cannot depend on any single test, the evidence afforded by several is often conclusive and satisfactory, and in this case it was acknowledged afterward that cottonseed oil was one of the adulterants.—*Amer. Chem. Journal.*

A SYNOPSIS OF ANÆSTHETICS.

By B. W. RICHARDSON, M.D.

UNDER the impression that it may prove of some service, for reference, to the learned scholars who are about to discuss the subject of anæsthesia at the forthcoming meeting of the British Medical Association at Cardiff, I have constructed, in the following essay, a synoptical view of all the important general anæsthetics that have been discovered from the revival of the practice of anæsthesia in 1846. It is thirty-nine years this year since I first took part in the administration of anæsthetic agents, and as every one of those to be named in the synopsis has passed through my hands for administration, either to man or to one of the lower animals, I write upon them with an advantage which is to a large extent exceptional, and which is, I trust, a sufficient apology for the present offering.

In the synopsis the following points are kept in view:

1. For the sake of ready reference the anæsthetics are placed in alphabetical order, both in series and in detail.

2. Each series starts from what is called the anæsthetic base. This means, for reasons I have assigned in another essay, that every anæsthetic derives its narcotic power from a certain definite chemical element, or chemical combination of elements, which plays its part independently of all other elements that may be combined with it.

3. The physical properties of each anæsthetic are briefly stated, including the chemical construction; the specific gravity in the case of fluids; the boiling points Cent. and Fahr.; the vapor density; and the solubility in the blood when that is fairly known. The reader will please remember under this head that water as 1,000 is taken as the standard for specific gravity (sp. gr.), and hydrogen = 1 as the standard for vapor density.

4. An epitome is offered of the more important comparisons in relation to the physiological action of the substances specified.

5. The anæsthetic value of each substance is estimated, as far as I have been able to appraise it, from direct observation of its action.

6. The date of introduction and the name of the first experimentalist of each anæsthetic are supplied in order of priority of original research.

7. The modern chemical nomenclature of all the substances is supplied. This has changed so much since the date of the commencement of anæsthetic research, that it becomes a difficulty to present the substances, as they were known under their old names, in the new names assigned to them, without creating some confusion. I have done my best, however, to put the anæsthetics as nearly as possible into their most modern denominations, and in such manner as to make the transitions easy as well as intelligible.

I. AMYL SERIES. ANÆSTHETIC BASE, AMYL (C_5H_{11}). A GAS. VAPOR DENSITY, 35·6. H=1.

Amylene (C_5H_{10}).

Physical properties.—A colorless fluid, sp. gr. 0·659 at 60° F. Vapor density, 35. Boiling point, 35° C., 95° F. Solubility in blood, 1 in 9,000. Vapor burns in air.

Physiological properties.—Odor of vapor, like wood spirit, not pungent. Quantity of fluid required for complete anæsthesia, 4 to 8 fluid drachms. Required charge of air by vapor, 15 per cent. Anæsthesia rapidly produced, with short but sharp second or spasmodic stage. Consciousness sometimes apparently retained during insensibility, as in somnambulism. Recovery rapid, with freedom generally from all after effect. Vomiting extremely rare.

Anæsthetic value.—Doubtful. Caused two deaths in 238 administrations between November, 1856, and July, 1857. Sudden failure of cardiac motion is the source of danger from amylene.

Date of introduction, 1856.—John Snow, M.D.

Amyl Chloride ($C_5H_{11}Cl$).

Physical properties.—A colorless fluid, sp. gr. 0·886. Vapor density, 53·25. Boiling point, 102° C., 215·6° F. Vapor burns in air.

Physiological properties.—Odor of vapor slightly pungent. Quantity of fluid required for complete anæsthesia, 6 to 8 fluid drachms. Required charge of air, 10 per cent. Action slow, with very slight rigidity in second stage. Anæsthesia extremely profound and prolonged. Animal temperature much reduced. Recovery rapid when it commences. Vomiting frequent. The great peculiarity in the action of amyl chloride is in the reduction of animal temperature. In one instance, in the rabbit, temperature fell from 103° F. to 82° F., 21 degrees, yet perfect recovery, in warm air, followed.

Anæsthetic value.—Anæsthesia too slow and profound for ordinary practice, but might be valuable for reduction of high febrile temperatures. After death, cardiac action is long persistent. Blood fluid, but of natural color on both sides. Red corpuscles shrunken and elongated, with truncated ends, some stellate. The brain left bloodless, and of purest white.

Date of introduction, 1869.—B. W. Richardson, M.D.

Amyl Hydride ($C_5H_{11}H$).

Physical properties.—A colorless fluid, sp. gr. 0·625. Vapor density, 36. Boiling point, 30° C., 86° F. Solubility in blood undetermined, but not greater than one in 15,000 parts. Vapor burns in air.

Physiological properties.—Vapor odorless, and free of pungency. Quantity of fluid required for complete anæsthesia, 6 to 12 fluid drachms. Required charge of air by vapor, 40 per cent. Anæsthesia very rapid, profound in two minutes, with short period of spasmodic movements. Recovery very rapid, without vomiting. The temperature of the body unchanged.

Anæsthetic value.—Action extremely rapid, but dangerous, probably from insolubility of vapor in blood. Heart easily paralyzed, but irritability of voluntary muscles long retained.

Date of introduction, 1867.—J. Bigelow, M.D.; B. W. Richardson, M.D. (1867).

II. BUTYL SERIES. ANÆSTHETIC BASE, BUTYL (C_4H_9). A GAS. VAPOR DENSITY, 28·5.

Butyl Chloride (C_4H_9Cl).

Physical properties.—A colorless fluid, sp. gr. 0·810. Vapor density, 46·25, Boiling point, 70° C., 158° F. Solubility in blood undetermined. Vapor burns in air.

Physiological properties.—Practically identical with those of amyl chloride.

Anæsthetic value.—Practically the same as for amyl chloride.

Date of introduction, 1869.—B. W. Richardson, M.D.

Butyl Hydride (C_4H_9H).

Physical properties.—A permanent gas at ordinary temperatures. Vapor density, 29. Burns in air.

Physiological properties.—Same as for amyl hydride, but action more rapidly developed.

Anæsthetic value.—Same as for amyl hydride, but, being a gas, less practical for administration.

Date of introduction, 1867.—B. W. Richardson, M.D.

III. BENZINE SERIES. ANÆSTHETIC BASE, BENZINE (C_6H_6). FLUID. VAPOR DENSITY, 39.

Benzine or Benzole (C_6H_6).

Physical properties.—A colorless fluid, sp. gr. 0·885. Vapor density, 39. Boiling point, 82° C., 179·6° F. Solubility in blood undetermined. Vapor burns in air.

Physiological properties.—Vapor heavy, and disagreeable to breathe. Action determinate, but slow.

Anæsthetic value.—Very indifferent, and after effects severe and prolonged.

Date of introduction, 1848.—J. Snow, M.D., and Sir J. Simpson, M.D. T. Nunneley (1849).

IV. CARBON SERIES. ANÆSTHETIC BASE, CARBON (C). A SOLID. COMBINING WEIGHT, 12.

Carbon Bisulphide (CS_2).

Physical properties.—A colorless fluid, sp. gr. 1·272. Vapor density, 38. Boiling point, 43° C., 109·4° F. Solubility in blood undetermined. Vapor burns in air.

Physiological properties.—When perfectly pure, of pleasant ethereal odor and free of pungency. Quantity for complete anæsthesia, 4 to 8 fluid drachms. Required quantity of vapor in air, 10 per cent. Anæsthesia very rapid, produced in from three to five minutes, with brief spasmodic stage. Recovery rapid and complete, with few bad effects. Reduction of animal temperature under deep anæsthesia, 2° F.

Anæsthetic value.—Not as yet determined. From experiments on inferior animals it seems to be very safe. Death in the vapor is gradual, the circulation outliving the respiration. In one animal, a dog, author observed life return, spontaneously, after respiration had ceased for seven minutes.

Date of introduction, 1849.—T. Nunneley. Harold Thanlow, M.D. (1850). B. W. Richardson, M.D. (1868).

Carbon Dioxide (CO_2).

Physical properties.—A colorless gas. Vapor density, 22. Extinguishes flame.

Physiological properties.—Inodorous, slightly pungent to breathe; air containing 25 per cent. of gas produces rapid insensibility. Insensibility deep, with convulsive action, asphyxia, and reduction of temperature.

Anæsthetic value.—Not as yet fully investigated. Death apparently from asphyxia, with respiration failing primarily and the muscular irritability becoming rapidly exhausted. After effects of recovery from deep anæsthesia are neither very prolonged nor severe.

Date of introduction, 1848.—J. Snow, M.D. T. Nunneley (1849). B. W. Richardson, M.D. (1852).

Carbonic Oxide (CO).

Physical properties.—A gas. Vapor density, 14. Vapor burns in air.

Physiological properties.—Almost inodorous, and breathed without irritation. Five per cent. in air causes rapid anæsthesia, with convulsive action, and fall of temperature 2° F. under deep narcotism.

Anæsthetic value.—Too dangerous for general use as an anæsthetic, although on lower animals it has been used for operations many times by the author. After death both venous and arterial blood of a bright red color.

Date of introduction, 1849.—T. Nunneley. J. Snow, M.D. (1852). Thornton Herapath (1852). B. W. Richardson, M.D. (1852).

Carbon Tetrachloride (CCl_4).

Physical properties.—A colorless fluid, sp. gr. 1·560. Vapor density, 77. Boiling point, 77° C., 170·6° F. Solubility in blood undetermined. Vapor extinguishes flame.

Physiological properties.—Vapor rather pleasant, with little pungency. Quantity for complete anæsthesia, 4 to 8 fluid drachms. Required charge of air by vapor, 5 to 10 per cent. Anæsthesia very slow and prolonged when induced. Convulsive stage long and acute.

Anæsthetic value.—Indifferent. Action too slow, recovered too prolonged. Temperature reduced during deep anæsthesia, 4° F.

Date of introduction, 1867.—Arthur Sansom, M.D., Protheroe Smith, M.D. (1867).

V. ETHYL AND ETHENE SERIES. ANÆSTHETIC BASES: ETHYL (C_2H_5). VAPOR DENSITY, 15. ETHENE (C_2H_4). VAPOR DENSITY, 14.

Ethyl Bromide (C_2H_5Br).

Physical properties.—A colorless fluid, sp. gr. 1·473. Vapor density, 54·5. Boiling point, 41° C., 105·8° F. Solubility in blood undetermined. Vapor burns with green flame.

Physiological properties.—Vapor ethereal, slightly pungent, rather irritating to inhale. Quantity required for complete anæsthesia, 1 to 6 fluid drachms. Required charge of air by vapor, from 5 to 10 per cent. Action rapid and effective, with scarcely any second or spasmodic stage. Recovery from deep narcotism in from four to five minutes, without bad effects. During full anæsthesia animal temperature reduced 2° F.

Anæsthetic value.—Was considered by Nunneley to be one of the best of anæsthetics, in which view I concur. Objections to its use are its cost and instability as a compound. No death from it has occurred in the human subject. In death induced by it in lower animals, the respiration and circulation fail together.

Date of introduction, 1849.—T. Nunneley. M. Robin (1850). B. W. Richardson, M.D. (1870).

Ethyl Chloride (C_2H_5Cl).

Physical properties.—A very volatile fluid, sp. gr. 0·921. Vapor density, 32·25. Boiling point, 11° C., 51·8° F. Solubility in blood undetermined. Vapor burns in air.

Physiological properties.—Vapor very pleasant to breathe. Quantity of fluid required for complete anæsthesia, 8 to 12 drachms. Required charge of air by vapor, 10 to 15 per cent. Anæsthesia moderately quick, with rather long spasmodic stage and, occasionally, vomiting.

Anæsthetic value.—A good anæsthetic, but too volatile for ordinary use as a fluid.

Date of introduction, 1849.—T. Nunneley. J. Snow, M.D., and B. W. Richardson, conjointly (1852).

Ethyl Hydride (C_2H_5H).

Physical properties.—A gas at ordinary temperatures. Vapor density, 15. Solubility in blood undetermined. Burns in air.

Physiological properties.—Generally the same as for amyl hydride.

Anæsthetic value.—Practically the same as for amyl hydride, but less manageable, owing to its being a gas.

Date of introduction, 1867.—B. W. Richardson, M.D.

Ethyl Oxide, Ethylic Ether ($C_4H_{10}O$).

Physical properties.—A colorless, mobile fluid, sp. gr. 0·720. Vapor density, 37. Boiling point, 35° C., 95° F. Solubility in blood, 1 part in 10 at 98° F. Vapor burns in air.

Physiological properties.—Vapor rather oppressive to breathe, and to some irritating. Quantity required for complete anæsthesia, 6 to 12 fluid drachms. Required charge of air by vapor at 60° F., 20 per cent. Action steady and rather slow, with moderate spasmodic stage. Recovery slow, and followed often by nausea, ethereal eructation, and oppression. Reduction of animal temperature in deep anæsthesia, 2° F.

Anæsthetic value.—Considered altogether to be the safest practical anæsthetic for general surgery. Administration has nevertheless been attended with fatal results. Andrews' estimate of one death to 23,204 administrations is probably an understatement. In death by ether the circulation, as a rule, outlives the respiration; in animals always, according to my observation.

Date of introduction, 1844–45.—Horace Wells. W. T. G. Morton, M.D. (1846). C. T. Jackson, M.D. (1846). First operation under ether by Morton, September 30, 1846.

Ethene, Olefiant Gas (C_2H_4).

Physical properties.—A permanent gas at ordinary temperatures. Vapor density, 14. Solubility in blood undetermined. Burns in air.

Physiological properties.—Inodorous and pleasant to breathe. Required charge of air by gas, 10 to 15 per cent. Anæsthesia rapidly produced, with short spasmodic stage. Recovery rapid, without bad effects.

Anæsthetic value.—A good anæsthetic, but inconvenient from being a gas. Respiration ceases before the circulation.

Date of introduction, 1849.—T. Nunneley. B. W. Richardson, M.D. (1865).

Ethene Chloride (*Dutch Liquid*) ($C_2H_4Cl_2$).

Physical properties.—A colorless sweet fluid of pleasant ethereal odor, sp. gr. 1·271. Vapor density, 49·5. Boiling point, 85° C., 185° F. Solubility in blood undetermined. Vapor burns in air with green light.

Physiological properties.—Vapor pleasant to inhale. Quantity required for complete anæsthesia, 2 to 8 fluid drachms. Required charge of air by vapor, 5 to 10 per cent. Stages induced slowly, with rather long spasmodic period. Recovery slow, with, in rare cases, vomiting.

Anæsthetic value.—A good anæsthetic, very much like chloroform in its action, but less rapid. Circulation and respiration fail, under it, together. Deserves more experimental study.

Date of introduction, 1846.—Sir J. Simpson, M.D. John Snow, M.D. (1848). R. Glover, M.D. (1848). B. W. Richardson, M.D. (1851).

Ethene or Ethylene Dichloride (*Monochlorinated Chloride of Ethyl*) ($C_2H_4Cl_2$).

Physical properties.—A colorless fluid, sp. gr. 1·174. Vapor density, 49·5. Boiling point, 64° C. 147·2° F. Solubility in blood undetermined. Vapor burns in air with greenish flame.

Physiological properties.—Vapor pleasant to breathe. Quantity required for complete anæsthesia, 2 to 8 drachms. Required charge of air by vapor, from 5 to 10 per cent. Anæsthesia produced rather more rapidly than by chloroform, with second or spasmodic stage sometimes acute. Recovery easy, and with no important after effects. Vomiting a less frequent accompaniment than after chloroform.

Anæsthetic value.—Snow, who introduced this anæsthetic, and who was seized with his fatal attack while writing upon it, told me he estimated its value as equal to chloroform—an estimate which has been sustained by later experience. The anæsthetic has, however, more than once proved fatal, apparently from failure of the circulation, although in my own experiments with it on lower animals I once restored a rabbit to life by artificial respiration seven minutes after the natural respiration had ceased.

Date of introduction, 1851.—J. Snow, M.D. O. Liebreich, M.D. (1869). B. W. Richardson, M.D. (1871).

(*To be continued.*)

STANDARD PULSE READINGS.

AN ATTEMPT TO READ SPHYGMOGRAPHIC TRACINGS FROM A NATURAL STANDARD, BY A STEEL-YARD BALANCE AND AN AUTOMATIC PULSE-METER CHART.

By Dr. B. W. RICHARDSON.

SOON after Dr. Pond, of Rutland, U. S. A., introduced to the profession his beautiful new sphygmograph, I essayed so to adapt it as to get from it a standard by which all who are engaged in sphygmographic work could read their tracings methodically. Later on, when Dr. Dudgeon's improved instrument came into use, I pursued the attempt with it; and now I have so far advanced as to be able to bring forward the first results of the inquiry.

For all writing purposes and for perfect conveniency, Dr. Dudgeon's sphygmograph may be taken as well nigh perfect. What I found wanting in it, as in Pond's, and what I have attempted to supply, have been the means of applying accurately and easily the pressure upon the pulse, and of registering the reading so as to be able to obtain a natural standard, I mean a standard from a natural pulse, that will determine, from one uniform reading or constant, all unnatural or morbid variations, and will be worked automatically.

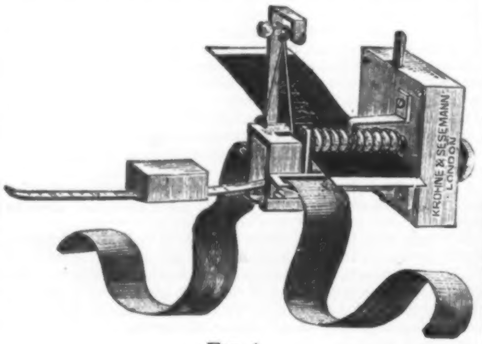


FIG. 1.

THE STEEL-YARD BALANCE.

To effect the weighing part, or the means for determining the pressure, I got Mr. Krohne—of the firm Krohne & Sesemann, who has rendered me the most useful aid in this work—to remove from my Dudgeon's sphygmograph the pressure gauge devised by its inventor, and to introduce instead a steel-yard balance, which projects as a weighing bar from the fore part of the instrument, as shown in the diagram (Fig. 1); the bar, which is carefully graduated, will weigh from one ounce to six ounces. The weight, which moves along the bar, is arranged in the same manner as in the instrument for measuring time in music, the metronome, and can be made to glide from one degree to another with the utmost ease.

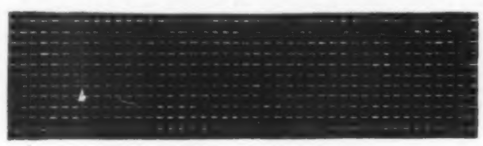


FIG. 2.

In weighing the pulse with this balance, the sphygmograph is placed on the wrist in the usual way; and when the pulse is found, by the regular movements of the needle on the recording paper, the weight is gradually moved up and down the scale, until the balance between the pressure which holds the instrument firmly in position and the pressure exerted by the steel-yard is precisely determined. Then the recording paper is allowed to traverse the stage under the clockwork action, and the record is written off by the needle.

As a general practice, I take the reading at first with a three-ounce pressure from the balance. But I never omit to test the full pressure later on. I fix the instrument with my left hand, by means of the straps which pass from it round the wrists, so firmly that I may, by movement of the steel-yard weight, find what is the longest up-stroke that can be obtained. Having found that, I let the recording paper traverse the stage to take the record. For holding the instrument steadily in its position, I use two perforated leather straps of equal length, attached to the instrument on each side. Over these I fit a movable steel clip, which gives great firmness with ease of movement. With properly acquired skill in manipulation, the pulse may be taken by the instrument almost as readily as by the finger itself.

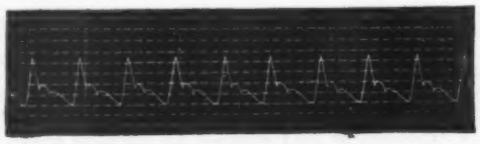


FIG. 3.

AN AUTOMATIC SPHYGMOGRAPHIC CHART.

I now come to the second, and I think more important, improvement in the pulse reading process. This introduces a plan by which each record is measured, as it is taken, on a series of vertical and horizontal lines produced on the carbonized paper at the same moment as the pulse curves are written. The plan is as follows:

The carbonized paper, which traverses the stage to receive the impressions from the needle, and which is moved by the pulse, has hitherto been carried along by the motion of a smooth circular rod or bearing, made to rotate by the clock represented in the square box in diagram 1. Into this revolving bar I have now had set a row of sharp edges, which in revolving on the carbon cut a series of lines of equal distance from each other along the whole length of the paper. These lines are so arranged that they leave on the paper ten horizontal spaces, or degrees, each degree two millimeters apart. At the same time, the sharp blades are divided transversely, so as to cut also a series of vertical dotted lines, or degrees, each two millimeters apart. When, therefore, the carbonized paper is made to traverse the stage by the clock movement, with the needle at rest, it is marked out by a set of measuring lines, horizontal and vertical, upon which the movements of the pulse are written when the needle is moved by it. This constitutes the scale, or chart, on which the standard readings of the radial pulse are taken. In its open form the scale is sketched in the diagram (Fig. 2).

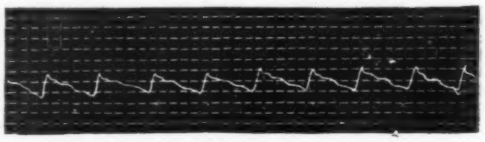


FIG. 4.

In bringing this scale into action, no more preparation is required than for the ordinary paper. The change is effected entirely by the sphygmograph itself, which cuts the carbon, automatically, at the same time that the needle is marking the tracings produced by the pulse. There is, therefore, neither addition of time nor of labor to the operator.

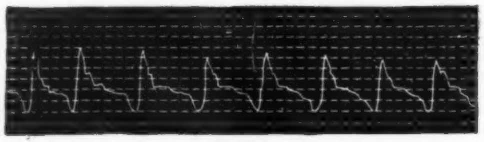


FIG. 5.

In order to produce the pulse readings with the measuring scale the carbonized paper is made to traverse the stage with the needle set in motion by the pulse, after the correct pulse pressure has been found. The result is a reading as shown in the diagram (Fig. 3).

As will be seen, the pulse tracings cross the standard or chart lines, and admit of being accurately measured in respect to the ascending or ventricular movement of the pulse; the first descending movement; the second short ascent; the second short descent; the third short ascent; and the third final descent down to the angle where the next similar series of movements, or, as they are sometimes called, "events," take their start.*

This diagram shows the order of movement over the lines and degrees, but it also shows more. It gives, as correctly as I can render it from the twenty-five readings of the right radial pulse of healthy persons between thirty and thirty-five years of age, and in conditions as closely natural as it is possible to obtain, the normal pulse standard or constant, while the pulse is lifting the steel-yard weight balanced at four ounces, with the subject in the sitting posture.

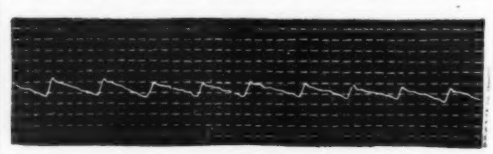


FIG. 6.

Read by this, the scale shows that in the natural pulse the tracings should be:

Four degrees and a half, or nine mm., on the scale for the long ascending straight line—systolic tracing.

Three degrees, or six mm., for the first descending line—receding ventricular tracing.

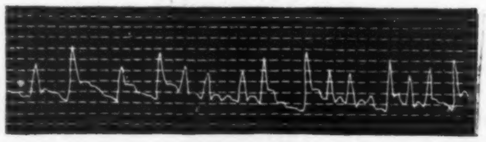


FIG. 7.

Half a degree, or one mm., for the second ascending line—primary arterial tracing.

* These tracings of the radial pulse, as I read them, from an attempt to reproduce them by means of an outside mechanism resembling in its action the circulatory movements, are caused in a way the description of which differs somewhat from that usually given. I shall explain this more fully in a future essay; but, tentatively, I may state here that the tracings seem to me to indicate the following order of events: (1) the long ascending, nearly straight line indicates the full pressure of blood from the contracting left ventricle; (2) the first oblique descending line, the decline of the ventricular pressure; (3) the second short ascending line or curve, the primary arterial recoil; (4) the second short descending line the decline of arterial recoil; (5) the third short ascending line or curve, the check or chuck from the closure and tension of the aortic valves; (6) the last descending oblique line, the subsidence of the arterial wave, under which the artery is left at rest, but filled with its column of blood awaiting the next charge from the ventricle.

One degree, or two mm., for the second descending line—receding arterial tracing.

Half a degree, or one mm., for the third ascending line—aortic check.

One degree and a half, or three mm., for last descending oblique line—subsiding arterial wave tracing.

In all, eleven degrees, or twenty-one mm.

The above are the natural measurements, taken step by step, as vertical and oblique movements. I have next to speak of them as horizontal measurements, and as measurements of time.

The clock in the sphygmograph, with which these tracings were made, is so "set" that the period of passage of the surface of carbonized paper occupies precisely the sixth part of a minute, or ten seconds. The number of each ascending tracing is consequently the number of completed pulse movements in the sixth of a minute. Let the number of straight upright lines across the scale be multiplied by six, and the rate of the pulse per minute is arrived at, and may be estimated fairly from the number seventy-two as a natural mean or standard. Once more, let it be observed that the distance apart of each upright line, horizontally, is precisely the length of the line itself, so that the space included in a perfected pulse movement, from the first point of impulse to the last point of movement, is a square of four and a half degrees, or nine mm.

The directions and curves of the descending or oblique line, from the top of one upright line to the base of the next, require a moment's study. The course of the first descent is from the top down to the space between the first and second lines above the base line of all the impulse or ascending strokes, and one degree distant, horizontally, from the impulse stroke; it then curves upward half a degree, and falls, two degrees horizontally from the impulse stroke, on to the line immediately above the base line; it rises again half a degree; it descends upon the same line, three degrees horizontally from the impulse stroke; and finally it curves through one degree, to the close of the circuit.*

VARIATIONS IN PULSE READINGS.

We will now turn to a few variations of pulse readings from the natural standard, in order to show the application of the standard to practice.

In diagram (Fig. 4) is the reading of a pulse which is not natural. The impulse stroke is one degree and a half below the standard. The primary descent is one degree and a half shorter than natural; the first arterial tracing is nearly horizontal in its course; the second decline and aortic tracings are scarcely defined; and the distance between one impulse stroke and another is two degrees longer than the impulse stroke, instead of being of the same length. The number of completed movements in the scale was one hundred and fourteen instead of seventy-two, and the full pressure borne by the pulse was three ounces.

In diagnosis, this pulse reading is one in which the systole is rapid and short; the delivery of blood feeble; the primary arterial recoil slowly and feebly developed, owing to imperfect resilience; the aortic closure and tension weak and deficient; and the number of movements increased nearly one-third per minute.

The case from which the reading was taken was one of phthisis pulmonalis at the commencement of the third stage, in a man twenty-eight years of age, and at a time when his circulation was at its best. The reading is so typical that it almost of itself tells the disease. Feeble heart, attenuated nutrition, relaxed arterial vessels, rapid action.

In diagram (Fig. 5) the conditions are entirely changed. In this reading the impulse tracing is one degree and a half above the standard; the first descent is irregular; the arterial recoil is sharp and short; the second decline is prolonged half a degree; the aortic line is horizontal; the last descent is prolonged half a degree; and the interspace of the impulse distance, irregular in one instance, is correct in the rest. The number of completed movements was at the rate of sixty-six per minute, and the full pressure of the pulse was four ounces.

The diagnosis from this pulse reading would be that of a heart slightly enlarged and powerful; a recoil of the arteries upon the aortic valvular surface, sharp and powerful; an aortic closure, not perfected with the first impact of blood; the aortic valves a little unduly distended by the blood pressure on them; the secondary recoil slow and sustained; the circulation slow.

The subject of this reading was a man fifty-four years of age, of very active habits, and in all respects well, except that, now and then, he was "conscious of having a heart by feeling its movement under excitement, and of experiencing a sensation of a slight irregularity."

In diagram (Fig. 6) the impulse stroke is, at its best, two degrees short, while the other events connected with the oblique descending course are scarcely definable; the impulse distances are equal, but nearly three times as long as the impulse itself. The rate of movement was 74 per minute, and the full pressure of blood was three ounces.

These readings, extremely characteristic, would yield a diagnosis of feeble heart; feeble arterial recoil; slight pressure on the aortic valves; a prolonged and feeble secondary recoil; the number of heart strokes per minute natural; and the motion equal.

The reading was from a man of middle age, who, in fair health generally, and of light build, suffers severely, and has suffered from his first days, with feeble circulation, cold extremities, and, when the weather is wintry, from chilblains, a condition which, as indicating a long range of similar cases, might appropriately be called cases or conditions of *chilblain circulation*.

In diagram (Fig. 7) there is a reading of a striking character, in which, as will be observed, there are a number of major and minor impulses. The impulse is sometimes through five degrees, at other times two; the primary arterial tracing is irregular and feeble; the third ascent, from the aortic check—sometimes single, sometimes double—is variable from one and a half to two degrees, and the impulse distances are unequal. The rate of movement was one hundred and twenty per minute, the full pressure three ounces.

The diagnosis in this case would be intermediate intermittency of the heart from mechanical valvular impairment, probably mitral regurgitation; weak arterial tension; rapidity of stroke; and variability, due to irregular contraction of the left ventricle.

The reading was taken from a gentleman sixty-four years old, who was in good health, except for the cardiac disturbance, called by him "constant palpitation," and produced, as the stethoscopic signs indicated, by regurgitant mitral disease.

I shall have opportunity in future to enter into many other details of pulse readings from the standard method above described. It is sufficient, at this moment, to explain the principle on which that method is based, and the readiness with which it may be applied. I trust it will bring the art of sphygmography, or pulse reading, to such a precise bearing that practitioners who adopt it may be able to record their observations with the same readiness and exactitude as they now record the varying temperatures of the body during disease, from the standard temperature of health marked on the clinical thermometer.—*The Asclepiad.*

* It may assist the memory to suggest that, if in the reading above given all the lines of the scale were removed except four above the base line from which the impulse stroke starts, and if the five lines thus left were taken as a treble clef in music, the course of the tracings on them would be from E to upper G; from upper G to A below; from A to B; from B to G below; from G to A; and from A back to lower E.

[AMERICAN NATURALIST.]

HUMAN REMAINS FOUND NEAR THE CITY OF MEXICO.

By MARIANO DE LA BARCENA.

IN the month of January, 1884, some excavations were being made, by means of dynamite, at the foot of the small hill known as "*Penon de los Banos*," some four kilometers east of the city of Mexico. The excavations were made with the object of quarrying building stone for the Military Shooting School, which is being constructed near the Penon and under the supervision of Colonel Don Adolfo Obregon. This gentleman, at the beginning of January, was informed that among the rocks loosened by the dynamite some bones were to be found, and he accordingly collected and delivered them to the Minister of Public Works, Don Carlos Pacheco, who appointed the writer to make a study of them. The preliminary examination being made, I presented them to the Mexican Society of Natural History, giving at the same time public notice of so important a discovery.

Some days afterward I explored the formation in which the bones were found, continuing my studies with the co-operation of Don Antonio del Castillo, professor of geology, whom I invited to take part in my investigations; both making up a report which has lately been published in Mexico.

The human remains are firmly embedded in a rock formed of silicified calcareous tufa, very hard and of a brownish-gray color. The cranium, with the lower and upper maxillæ and fragments of the collar-bone, vertebræ, ribs, and bones from the upper and lower limbs, are exposed. The bones lie in disorder, proving that the rock in which the skeleton was found suffered an upheaval before consolidation, a circumstance which an examination of the ground further verifies. The bones present a yellowish appearance and the characteristic aspects of fossilization, it being noteworthy that they are not coated with layers of the calcareous rock as is observed in the recent deposits, but are firmly embedded in the stone, which also fills the cells of the tissue.

Several distinct formations and rocks are seen in the locality where the bones were found; toward the center rises the small hill "*del Penon*," consisting of volcanic porphyries; on the base to the north there appear first a clearly recent formation made up of vegetable earth, marl, and ceramical remains, which in the upper part are modern, and in the lower belong to the Aztec ceramics. Under this recent formation are the calcareous layers in which the humain remains were found.

These layers crop out with a rise toward the northern boundary, forming the end of an esplanade which surrounds the hill, and is three meters above the actual level of the waters of Lake Tezcoco. The layer of hardened rock does not extend with regularity the whole distance from the before mentioned edge to the foot of the hill, some intervening spaces occurring in which this rock does not appear; the resulting hollows being filled with recent ground. This circumstance, as well as the appearance of the layers of calcareous tufa, prove that this rock was upheaved, after the deposit of the human bones, by the igneous rocks which crop out in the neighborhood of the hill, forming dikes. This upheaval is also verified by the numerous small veins which are found in different directions on the ground.

In order to clearly establish the age which the deposit of the human bones might have, the best scientific method would be to find some animal fossil remains in the same formation which would distinctly mark the age of the layers of that calcareous rock, but until now, notwithstanding the many searches made, it has not yet been possible to find any traces of extinct animals; neither has there been found any vestige of ceramics or other remains that might indicate that these rocks were clearly modern, as among them the only things found were the human bones, roots converted into menilite, and some small indeterminable lacustrine shells formed by the same calcareous substance. These shells belong to genera which have lived in Quaternary as well as present waters, it having been impossible to determine their species on account of the bad state of preservation in which they were found.

In the region to the south of the hill more modern calcareous rocks are seen, and thicker deposits of recent ground with remains of Aztec ceramics.

Not being therefore able to utilize the paleontological data for determining the age of these calcareous layers, we must fall back on the inspection of the ground.

Two facts seem at once to reveal that, even supposing the formation to belong to the present age, it must be of remote antiquity. These facts are: The elevation of the ground above the actual level of the Lake of Tezcoco, and the remarkable hardness of the rock in which the bones are found, different from the other calcareous rocks that contain remains of ceramics or roots of plants clearly modern. The upheaval of the lacustrine layers which contain the human remains might have taken place during the diminution and retirement of the waters of the lake, or by upheaval of volcanic rocks.

Interior View of Palate and both Jaws of Left Side of the Fossil Man of Mexico. From a photograph of the original by Cruces y Ca.

External View of Left Side and Front of Jaws of the Fossil Man of Mexico. From a photograph of the original by Cruces y Ca.

In the first case, it could have been occasioned either by a violent filtration of the water or a slow evaporation; but nowhere in the valley of Mexico are any traces to be found of a crack or opening through which the waters could have escaped, and which ought to appear outside of the present level of the lake, as, if it were below, all the water would have disappeared. If the lowering of level was due to evaporation, a theory which would be more admissible, because from the time of the conquest of Mexico to the present the submerged surfaces have notably diminished, the time necessary to have elapsed, in order that the level of the lake might fall three meters to its present one, must have been very long. What is most probable is, that the upheaval is due to volcanic action; for although until now no basalt has been discovered immediately underneath the place occupied by the hardened layers, yet dikes of that rock are to be seen in different directions at the foot of the hill, and even the volcanic masses which constitute it are found upheaved and inclined, demonstrating the succession of geological phenomena in that vicinity.

Let us now trace the origin of the silicified calcareous rock in which the bones were found, and which is different from the majority of the lacustrine rocks which occupy the valley of Mexico, these latter being, for the most part, thick and extensive layers of pumice, tufas, marls, volcanic ashes, clays, and alluvions.

In order to proceed with more certainty in this investigation, I compared the calcareous rock in question with those which resembled it most from other parts of Mexico, and found it could only be considered similar to those which are clearly of a hydrothermal origin.

The hot-water spring which exists in the eastern part of the hill Del Penon forms sediments somewhat similar to the silicified calcareous tufa; but these are on a small scale, and their formation is so slow as to preclude the belief that this spring could have filled all the immediate surroundings of the hill with deposits of such magnitude. What is most probable is, that in remote times there were great emissions of mineral thermal

waters through different fissures, and in several directions, whose appearance was simultaneous with the basaltic masses that form dikes at the foot of the hill, as in the faces of the rocks sedimentations similar to the referred ones are perceived, there being furthermore many small veins which cut through the basaltic masses and even the calcareous rock.

By this it is seen that a series of volcanic phenomena must have taken place in that spot, beginning before the human remains were deposited, and which further continued when the material which received them was but little consolidated.

The succession of these phenomena took place, without doubt, in the following way:

1st. Emission of thermal waters and appearance of basaltic rocks, unheaving the masses that formed the hill. These waters mixed with those of the lake which surrounded the hill, and extended over a large area of the valley of Mexico; the calcareous deposits gradually accumulated around the hill, and being still soft the human corpse was deposited upon them.

2d. When the bones were already embedded in the lacustrine deposit, there came a new volcanic upheaval which raised this deposit, as the higher level which it now occupies proves, and the disorder in which the bones of the skeleton appear.

3d. In the gaps which were left after this upheaval, modern lacustrine deposits were formed, which increase even at the present time.

It is to be remarked that in other parts of the valley of Mexico in connection with the Lake of Tezcoco, isolated deposits of this silicified calcareous rock are seen, showing that the volcanic upheaval extended over a large surface, and that the thermal waters appeared several times. One of these deposits is to be found at the height of two meters above the present ground among rocks of the hill Del Tepeyac, north of the city of Mexico.

The geological circumstances of the event once determined, and notwithstanding that the paleontological data are wanting that might mark with precision the relative age of that deposit, it is to be believed that it must be of remote antiquity, considering the circumstances which the mentioned rocks present, as well as the geological phenomena which have there taken place, and of which no notice is given in the hieroglyphics or traditions of the ancient Mexicans.

This consideration alone is enough to believe that the man of the Peñon is prehistoric. The odontological characteristics indicate that this man belonged to an unmixed race, the teeth being set with regularity and corresponding perfectly, the upper with the lower. They present the peculiarity, besides, that the canine teeth are not conical, but have the same shape as the incisors; a peculiarity which has been observed in other teeth found in very ancient graves of the Toltecs.

The size and shape of the bones of the limbs are those corresponding to a man of ordinary stature, and from the appearance of the teeth the man must have been about forty years old.

The greater part of the cranium having been destroyed, it was not possible to determine its diameters and thus classify it. The stratigraphical and lithological characteristics of the ground seem to indicate that the formation belongs to the upper Quaternary, or at least to the base of the present geological age.

It may as well be remarked that at the foot of the steep slope of the Tepeyac hill, near the place where the calcareous sediments are to be seen among the rocks of the hill, as was previously mentioned, some excavations were made, and Professor Don Antonio del Castillo found various bones of Quaternary animals enveloped in a calcareous rock similar to that of the Peñon. The distance between this hill and the Tepeyac is nearly three miles.

The excavations continue at the foot of the hill Del Peñon, with the object of quarrying building stone, and this will allow in the course of time some other data to be discovered which will clearly mark the geological age of the event; a tooth of a mastodon or an object of the present age would at once be the landmark assigning it a fixed page in the history of the earth. The authenticity of the fossil is not only determined by the report of Señor Obregon and the identity of the rock which contains the remains with the blocks that are being at present quarried at the foot of the hill, but I, myself, have determined this authenticity, having found part of the human remains still embedded in the ground rock.

I will conclude by mentioning other facts that indicate the antiquity of man in the valley of Mexico. Twelve years ago, in executing some works for the drainage of the valley, in the direction of Tequisquiac, numerous deposits were discovered belonging to Quaternary animals, such as elephants, mastodons, glyptodons, etc., and among one of these deposits a fossil bone was found carved by human hand and imitating an animal's head. Unfortunately, no care was taken to determine if it was found simultaneously with the bones of the Quaternary animals. The appearance of the carved bone and of the cuts and incisions which it has denote a remarkable antiquity, and it has characteristics of fossilization. Two years ago I discovered some remains of ancient ceramics in the pumice tufa which is under the basaltic lava formation found in the southeastern part of the valley of Mexico; the lava occupies a large area, and in some points its thickness is over two meters. No tradition makes any mention of this volcanic cataclysm before the existence of man in the valley of Mexico.

These are, at present, all the data I can give relative to the man Del Peñon. On my return to Mexico I will continue with a further investigation of the ground where the discovery was made, and will communicate anything new that may be found, in order to determine the anthropological importance which these human remains may have.

A NEW STATUE FOUND AT ROME.

THE bronze statue found lying in the bed of the Tiber recently has been successfully raised. This was a work of some difficulty, for it had evidently been flung into the river head foremost, and was found with the feet uppermost. The workmen first struck the metal plinth, which, being hollow, was supposed to be a large bronze plate. But on clearing the sand from below, the men quickly found the feet of the statue. It is a Bacchus, a little under life size, the head crowned with ivy leaves and berries. The left arm is flexed upward, the hand holding a long, vine-crowned thyrsus. The right hand hangs down, and is extended a little outward. The face is very slightly turned to the right, and the weight of the body rests on the right leg, the left being bent at the knee, with only the ball of the foot and toes touching the ground behind. The statue is perfect in every respect, with the exception of a clean fracture above the right ankle, and that the thyrsus is broken into three pieces, which have all been found. It is a work of great beauty, but, as far as it is possible to form a judgment, coated as it still is in many parts with Tiber sand, I am inclined to attribute it to the Græco-Roman rather than to any Greek school of art. The face is strictly ideal, the line of the nose straight, and the mouth and chin are clearly and symmetrically modeled in full accordance with the typical rendering of the divus. The eyes are of some artificial material to imitate nature, the iris being represented by globular concavities. Some are inclined to think the eyes are silver, but this cannot be ascertained until the incrustation of sand is removed, and that will not be a difficult task, for it is very loose. The bronze has a beautiful golden tint. The statue was found in the middle of the river, where the works are going on for sinking the foundations of the middle pier of the bridge which is to connect the new street through the Regola on one side and the Trastevere on the other, near the church of San Crisogono. This spot is but a short distance from the northern extremity of the island of St. Bartholomew, and as a portion, extending more or less to where the works are proceeding, was washed away during one of the inundations in the middle ages, it is probable that the statue may have been flung into the river from the northern point of that island, where stood a temple of Faunus, mentioned by Ovid in the "Fasti"—,

"Idibus agrestis fumant altaria Fauni
Hic ubi discretas insula rumpit aquas."

The recovery of three bronze statues within less than twelve months is something more than remarkable.—*London Times.*

AQUATIC RESPIRATION IN SOFT SHELLED TURTLES, ILLUSTRATING THE COMPARITIVE PHYSIOLOGY OF RESPIRATION.*

By S. H. and S. S. P. GAGE, of Ithaca.

1. IT was formerly supposed that in all reptiles the respiration was exclusively aerial at all periods of their life, and that the lungs were the only respiratory organs.

2. We have demonstrated that in soft shelled turtles (*Amyda mutica* and *Aspidonectes spirifer*) there is in addition a true aquatic respiration. This conclusion is indicated by three facts: (*a.*) These turtles remain most of the time in water, and for long periods—two to ten consecutive hours—not even raising their nostrils above the surface. (*b.*) While under water they fill and empty the mouth and pharynx by means of the hyoid apparatus; the general appearance of the movements being like the respiratory movements of a fish. (*c.*) The mucous membrane of the pharynx is covered with filamentous processes appearing like the villi of the small intestine of a mammal or the gill filaments of necturus. These are especially numerous along the hyoid arches and around the glottis.

But neither the time under water, the character of the movements, nor even the structure of the parts proves that true aquatic respiration occurs. Final proof of this is only obtained by a determination of the free gases in water in which the turtle has been confined without access to air. Water so tested showed that a turtle weighing 1 kilo. in ten hours removed from the water 71 milligrammes of free oxygen, and added to the water 318 milligrammes of carbon dioxide. This indicates a respiration, for the same body weight, about one-twentieth of that occurring in man.

That this respiration is due almost entirely to the pharynx and not to the skin is shown: (*a.*) By anæsthetization—the turtles being acted upon four or five times as quickly when kept entirely submerged in etherized water as when they were allowed to come to the surface as frequently as they desired. (*b.*) Nearly as great an amount of oxygen was removed from the water, and carbon dioxide added to it, by a turtle whose skin was entirely coated with vaseline as when unvaselined.

In some, at least, of the hard shelled turtles (the snapping and the painted turtles), similar movements of the hyoid apparatus were observed, and water was seen to enter the nostrils and be expelled from them, something as in the soft shelled turtles.

The pharynx expands and contracts with considerable regularity in all the turtles when they are in the air, the appearance being much as in frogs—but in turtles they are unnecessary for filling the lungs. In frogs, however, they are necessary for this purpose, but often the pharyngeal movements occur without any air being forced into the lungs.

It seems probable that as in aquatic turtles these movements are of use, in aquatic and land species the same movements may be useful for respiration in air, that is, the membrane lining the pharynx acts as a respiratory organ, whether the medium bathing it and containing the free oxygen be air or water.

These movements and their object, namely, respiration, thus seem to connect physiologically at least the turtles on the one hand with the lower vertebrates, namely, the amphibia and fishes, and on the other hand with the higher forms, as dog and man; for Garland has shown, that in the dog, and also in man, occur rhythmical pharyngeal movements which draw air into the pharynx, and expel it whenever there is a condition of great asphyxiation. It seems as though these pharyngeal movements reappear in the higher forms whenever the want of oxygen, for instance, in the article of death, becomes overwhelmingly great, as if there were an organic memory of the means by which in the dim past the want was supplied.

* Read before the American Association for the Advancement of Science at the Ann Arbor meeting.

BUNION SHIELDS AND VACCINATION.—Bunion shields are said to be in great demand for the protection of vaccination scabs. Happily this novel use of the shield is calculated to afford relief to the dealer's pocket as well as the purchaser's arm.

EXCAVATIONS IN NEW ORLEANS.

ON the 1st of August excavations were begun in New Orleans for the reception of the gas-holders of the new Municipal Gas Company. The turning up of the earth was followed by sickness in the neighborhood, and the Board of Health caused an investigation of the matter. It was ascertained that two excavations were being made, each about one hundred and thirty-five feet in circumference and about twenty-six feet deep. The contractor stated he had had about eighty men at work since August 3. Within a week after, one gang of forty men had experienced considerable sickness, thirty-four of the laborers having been taken sick with vomiting, purging, and fever. Another force of about the same number had also experienced sickness, but not to the same extent. It was ascertained that years ago the accumulating excreta from slaughter houses and cattle yards were thrown into the batture at this point. The excavation, as far as it has extended, does not expose river sand, but dark, offensive matter. The Board of Health, regarding the making of excavations of any character in the midsummer months as a menace to the public health, applied to the courts for an order forbidding further digging until October 1, which order was granted on the 8th Sept., and the work was stopped.—*Hydraulic and Sanitary Plumber.*

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